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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIII.—No. 2930.] *LONDON: FRIDAY, FEBRUARY 24, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

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BOILER FEED PUMPS.
See advertisement pages 27 and 67.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
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See half-page Advert. last week and next week. 9389

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Motherwell, near Glasgow. 9048

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Thos. Piggott & Co., Limited,
BIRMINGHAM. 7411
See Advertisement last week, page 91.

"Spencer-Hopwood" Patent WATER TUBE Boilers. *See page 80.* 577
Sole Makers: SPENCER-BONECOURT, LTD.,
Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD.,
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Cochran Boilers. MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 9047

Petter Oil Engines.
For Paraffin and Crude Oil.
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
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Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

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BUTTERWORTH BROS., Ltd.,
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Manchester. Od 9783

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9662
S. H. HEYWOOD & CO., LTD.,
REDDISH.

Fuller, Horsey, Sons & Cassell.
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in the
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of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
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Tubes and Fittings.
Sole Licencees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 75, Feb. 17.

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SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
EXCEPTIONAL SHALLOW DRAUGHT.
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by YARROWS, LIMITED, Victoria, British Columbia. 9563
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Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
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Address, BURNETT AVENUE, HULL.
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OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
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Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 97, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS.
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BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
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AUCTIONEERS, VALUERS AND SURVEYORS
for
ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 9866
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters.
9662
S. H. HEYWOOD & CO., LTD.,
REDDISH.

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28, 1921.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS,
CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and
DECK MACHINERY. 9364
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 60. 9952

Economy!
HIGH BOILER EFFICIENCIES
ARE OBTAINED BY INSTALLING
Todd Oil Burners
FUEL OIL BURNING SYSTEMS,
HEATERS, STRAINERS.
49-51, EASTCHEAP, LONDON, E.C.3.
TODD SHIPYARDS CORPORATION,
Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways.
25, Broadway, New York, U.S.A. 9960

The Glasgow Railway Engineering Company,
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London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 540

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO.,
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John Kirkaldy, Ltd.,
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Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9604

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(UP TO 35 TONS.)
9662
S. H. HEYWOOD & CO., LTD.
REDDISH.

One Wilson Navvy, 12 ton,
with swan neck and straight jib, Boiler pressure 100 lbs. per square inch, first-class order.
One 2 ft. gauge LOCOMOTIVE, 7 in. by 10 in. cyl., Boiler pressure 180 lbs., copper firebox, brass tubes.
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700 4 in. PRESSURE GAUGES, reading from 0—1000 lbs. per square inch.
MARSHALL, 27, Dobbie's Loan, Glasgow.
T 376

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
STEAM AND GAS KETTLES,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
ROW'S PATENTS.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8728

Yarrow Patent Water-tube Boilers.
9664
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9518
See Full Page Advt., page 64, Feb. 3.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 60. 3402

Taylor & Challen Presses
8195
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers,
Constitution Hill, BIRMINGHAM.
See Full page Advertisement page 62, Feb. 3.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 600

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"OILDAG" (Reg.) BRAND. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE.
"GREDAG"
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Locomotive Traversers
(ELECTRIC).
9662
S. H. HEYWOOD & CO., LTD.,
REDDISH.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
9727
See half-page Advertisement page 42, Feb. 17.

The Manchester Steam Users' ASSOCIATION.
For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

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Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 566

Inst.C.E. Exams.—Successes as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 28 years' professional experience. Address, 7434, Offices of ENGINEERING.

TENDERS.

BELFAST HARBOUR.

THE BELFAST HARBOUR COMMISSIONERS are prepared to receive

Tenders for the Construction of a DRAINAGE CULVERT and MANHOLES, &c. (total length about 1450 feet), in the neighbourhood of the Hamilton Road, all in accordance with Drawings, which may be seen at the Office of the Harbour Engineer, Mr. T. S. GILBERT, M.Inst.C.E., from whom copies of the Conditions of Contract, Specification, and Form of Tender may be obtained.

Tenders must be made on the Form provided for the purpose, and must be enclosed in a sealed envelope, endorsed "Tender for Drainage Culvert," and addressed to the undersigned and delivered not later than Monday, the 27th March, 1922.

The Commissioners do not bind themselves to accept the lowest or any tender.

D. J. OWEN,
General Manager and Secretary,
Harbour Office,
Belfast,
17th February, 1922. T 492

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for either or both of the following:—

(1.) 5 DECK SPAN GIRDER BRIDGES
100 feet span complete.
34 Ditto.

(2.) 5 DECK SPAN GIRDER BRIDGES
60 feet span complete.
2 Ditto. 40 feet span complete.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 20th February, 1922.

For each specification a fee of £1 1s. will be charged, which will not be returned.

Tenders to be submitted not later than Noon on Monday, 6th March, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
H. C. VOLKERS, T 503
for Managing Director.

GREAT NORTHERN RAILWAY (IRELAND).

PERMANENT WAY MATERIALS.

The Directors are prepared to receive

Tenders for the Supply of:—
BULL HEAD RAILS,
FLAT BOTTOM RAILS,
and
FISHPLATES.
of the British Standard Sections.
Also
CAST IRON CHAIRS
and
PERMANENT WAY FASTENINGS.

Specifications, Drawings, and Forms of Tender can be obtained from the Secretary.

Tenders, made out on forms supplied by the Company, should be delivered, under sealed cover, endorsed "Tender for Rails, &c.," not later than Ten a.m. on Monday, March 20th, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.
Amiens Street Station,
Dublin,
17th February, 1922. T 505

THE BURMA RAILWAYS CO., LTD.

The Board of Directors of the Burma Railways Company, Ltd., are prepared to receive

Tenders for the Supply of :—
(A) BOLTS, NUTS AND RIVETS.
(C) GALVANIZED WORK.
(C) 332½ tons, STEEL MATERIAL.

For each copy of the Specifications (A) & (B) a fee of 10s. will be charged, and for each copy of the Specification (C) a fee of 20s. will be charged, which fees are not returnable. Tenders, enclosed in sealed envelopes, endorsed "Tender for Bolts, Nuts and Rivets," or as the case may be, must be delivered at the Company's Offices not later than Twelve Noon on Tuesday, 7th March, 1922. The Directors do not bind themselves to accept any or the lowest Tender and reserve the right to divide the order.

By Order of the Board,
F. C. FRANKS,
Secretary.
199, Gresham House,
Old Broad Street,
London, E.C. 2.
22nd February, 1922. T 518

BILLINGE URBAN DISTRICT COUNCIL.

Tenders are Invited for the SUPPLY of 6in. CAST IRON PIPES (about 85 tons), with necessary Tees, Junctions, and other Special Pipes; 6in. SLUICE VALVES and CASINGS; Two 6in. METRES, &c.

Particulars on application to the Surveyor.

Sealed Tenders, endorsed "Pipes, &c.," to be forwarded on or before the 27th instant, addressed to the Clerk, Council Offices, Billinge.

The Council do not bind themselves to accept the lowest or any Tender.

ALFRED DARLINGTON,
Clerk.
Council Offices, Billinge,
15th February, 1922. T 496

Tenders are Invited by the GOVERNMENT of NEW SOUTH WALES for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of a CANTILEVER BRIDGE ACROSS SYDNEY HARBOUR from DAWES POINT to MILSON'S POINT, embracing a main span of 1600 ft. in the clear, centre to centre of main piers, or 2000 ft. centre to centre of anchor piers. The total length of bridge included in tender is 3816 ft., centre to centre of abutments. The deck of the bridge is to include four lines of railway, and a roadway 57 ft. wide, between main trusses; and cantilevered outside the main trusses on the western side, a footway 15 ft. wide, and on the eastern side a motor roadway 18 ft. wide. Copies of specification, including plans, general conditions, and schedule of quantities may be obtained on application to the undersigned.

To give any information required by Tenderers, Mr. J. J. C. BRADFIELD, Chief Engineer, will be in London during June and July, 1922, address care of the undersigned.

Tenders in accordance with the specification must reach the Under Secretary for Public Works, Sydney, not later than 31st October, 1922.

AGENT-GENERAL,
FOR NEW SOUTH WALES.
Australia House, Strand, London, W.C. 2.
December, 1921. T 34

COUNTY BOROUGH OF CROYDON.

PULVERISING PLANT FOR HOUSE REFUSE, SOUTH NORWOOD FARM.

NOTICE IS HEREBY GIVEN that the Council are prepared to receive:

Tenders for the Supply, DELIVERY and ERECTION of CRUSHING PLANT, CONVEYORS, STORAGE HOPPERS, ELECTRICAL MOTORS, SWITCHBOARDS and SHAFTING for the purpose of Pulverising House Refuse on the South Norwood Sewage Farm.

Plan of Site, Specification and Form of Tender may be obtained on application at the Borough Engineer's Office, Town Hall, Croydon, upon payment of a deposit of One Guinea, which will be returned upon receipt of a *bona fide* Tender.

Tenders on the prescribed form to be sent to me by Eleven o'clock in the forenoon of Tuesday, the 14th day of March, 1922, endorsed "Tender for Pulverising Plant, South Norwood Farm."

Tenders will only be received subject to the terms of the draft contract deposited at my office, and which may be inspected during office hours.

The Council will not be bound to accept the lowest or any Tender.

J. M. NEWNHAM,
Town Clerk.
Town Hall, Croydon,
15th February, 1922. T 501

HAVANT URBAN DISTRICT COUNCIL.

MAIN SEWERAGE AND SEWAGE DISPOSAL WORKS EXTENSION.

UNEMPLOYMENT RELIEF WORKS.

GENERAL CONTRACT No. 1.

The above Council invite

Tenders from Responsible Sewerage Contractors for these works, which comprise several miles of Stoneware and Cast Iron Sewers, with Manholes, Flushing Tanks, Ventilating Columns, &c., for draining the areas known as Denvilles, Lymbourn and Langstone, and the modification and extension of the existing Sewage Disposal Works, including 5 ft. diameter Tank Sewer, New Detritus Pits and Screening Chambers and Pump Well, New Engines and Pumps, Addition to existing Engine House, New Engine House at Langstone, Additions and Alterations to Sedimentation Tanks, New Percolation Filters, Humus Tanks, Storm Tanks, Sludge Beds, and other incidental work.

The Contract will be let on the basis of a FIXED PROFIT and FIXED SUMS for Administrative and Establishment Charges, and for the Supply and Use and Waste of all Plant.

The Contractor whose Tender is accepted will be required to find two securities to the satisfaction of the Council, to join him in a bond for the sum of £3500 for the due performance of the work, and to employ to the fullest extent local unemployed.

Plans may be seen and a copy of the Specification, Bills of Quantities, and Form of Tender, may be obtained from the Council's Consulting Engineer, Major T. J. MOSS-FLOWER, of 28, Victoria Street, Westminster, and Carlton Chambers, Baldwin Street, Bristol, at his BRISTOL Office, on and after March 1st, 1922, between the hours of Ten a.m. and Four p.m., on payment of a deposit of £10 Bank of England Note, which will be refunded provided a *bona fide* Tender be received and is not withdrawn before the sealing by the Council of one of the Tenders, and provided that any documents supplied be returned to the Engineer.

On production of a receipt for the deposit, persons tendering may inspect the PLANS at HAVANT on a day and at a time and place which will be communicated to them.

Sealed Tenders endorsed "Tender for Havant Main Sewerage and Sewage Disposal Works Extension, General Contract No. 1," are to be delivered at my Office not later than Twelve noon, on Tuesday, March 14th, 1922.

The lowest or any Tender not necessarily accepted.

By Order,
R. R. LONGCROFT,
Solicitor and Clerk to the Council.
Council Offices,
Havant, Hants.
February 18th, 1922. T 511

THE BENGAL & NORTH WESTERN RAILWAY COMPANY, LIMITED, and the ROHILKUND & KUMAON RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—
(A) 23½ tons COPPER INGOTS, &c.,
(B) 30 tons STRAND WIRE for Fencing,
(C) 40 tons RED LEAD and 8 tons WHITE LEAD,
(D) 236 Pairs WHEELS and AXLES,

as per Specification to be seen at the Company's Offices.

Tenders, addressed to the undersigned, and marked "Tender for Copper Ingots, &c.," or as the case may be, are to be lodged not later than Noon, on Monday, the 6th day of March, 1922.

For each Specification a fee of 10s. will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.
237, Gresham House,
Old Broad Street,
London, E.C. 2.
21st February, 1922. T 539

CITY OF LEICESTER.

STEAM BOILERS, ETC., FOR ABBEY SEWAGE PUMPING STATION.

The Sewage Works and Farms Committee invite

Tenders for :—
(1) LANCASHIRE BOILERS.
(2) MECHANICAL STOKERS and COAL CONVEYING PLANT.
(3) SETTING OF THE BOILERS.

Forms of Tender, etc., may be obtained at my office on payment of the sum of £2, which will be returned on the receipt of a *bona fide* Tender. Cheques, etc., to be made payable to the Corporation of Leicester.

Applications should state section desired.

Sealed Tenders on the forms supplied, addressed to the "Chairman of the Sewage Works and Farms Committee, Town Hall, Leicester," must be delivered not later than 20th March, 1922, and endorsed "Tender for Boilers, etc."

The Committee do not bind themselves to accept the lowest or any Tender.

H. GEORGE MAWBEY, M.Inst.C.E.,
City Engineer and Surveyor.
Town Hall, Leicester,
21st February, 1922. T 535

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby In- vited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place,
Strand,
London, W.C. 2.

SPECIFICATION No. 200. 22,000 volt 3-core CABLE and ACCESSORIES.

CHARGE:—
£2 2s. for the first two copies of Specification and 10s. 6d. per copy thereafter. These charges will be returned on receipt of a *bona fide* Tender.

PRELIMINARY DEPOSIT:—
A preliminary deposit of 1 per cent. (not exceeding one hundred pounds—£100) is to be lodged with Tender.

The Specification may be inspected at the above mentioned Office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne, not later than 29th April, 1922.

R. LIDBELOW,
Secretary.
State Electricity Commission of Victoria,
673, Bourke Street,
Melbourne,
Victoria,
AUSTRALIA. T 525

METROPOLITAN WATER BOARD.

TENDERS for the SUPPLY and FIXING of a LANCASHIRE BOILER, SUPERHEATER, PIPING and FEED PUMPS, at West Wickham, Kent.

The Metropolitan Water Board invite

Tenders for the Supply and FIXING of ONE LANCASHIRE BOILER, SUPERHEATER, PIPING, FEED PUMPS, &c., at their West Wickham Pumping Station, Kent.

Forms of Tender, Conditions of Contract, Specification and Drawing may be inspected without payment of fee at the Offices of the Board, Chief Engineer's Department, Room 183, New River Head, 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Thursday, February 23rd, 1922.

Contractors desirous of tendering may obtain the necessary documents from Mr. HENRY R. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £1 1s., which sum must be deposited with the Board's Accountant, and will be returned on receipt of a *bona fide* Tender, together with all incidental papers. Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m., Thursdays excepted (Saturdays Ten a.m. and Twelve noon).

Tenders, enclosed in sealed envelopes addressed to The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1, and endorsed "Tender for Boiler, West Wickham," must be delivered at the Offices of the Board, not later than Ten a.m., on Wednesday, March 22nd, 1922.

W. MOON,
Clerk of the Board,
Offices of the Board,
173, Rosebery Avenue, E.C. 1.
16th February, 1922. T 520

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of FOUR SUPERHEATED 4-6-0 type PASSENGER LOCOMOTIVES as per specification to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Locomotives," are to be lodged not later than Noon on Monday, the 27th day of March, 1922.

For each specification a fee of £1 will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By order of the Board,
E. A. NEVILLE,
Managing Director.
237, Gresham House, Old Broad Street,
London, E.C. 2. T 540
21st February, 1922.

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Borough Council invite

Quotations for the Supply, DELIVERY, and ERECTION of ONE 20-ton WEIGHBRIDGE at their Electricity Works.

Form of Quotation, with full particulars, may be obtained on application to Mr. G. G. BELL, Borough Electrical Engineer and Manager, Electricity Works, 85, Fulham Palace Road, Hammersmith, W. 6.

Quotations, endorsed "Quotation for Weighbridge," must be delivered to the Engineer and Manager not later than Four p.m. on Friday, 3rd March, 1922.

The Council do not bind themselves to accept the lowest or any quotation.

LESLIE GORDON,
Town Clerk.
Town Hall, Hammersmith, W. 6.
21st February, 1922. T 538

BUSINESS FOR SALE.

MACHINE TOOLS.

For Sale by Private Tender as a Going Concern, by order of the Receiver for the Debenture Holders.

The BUSINESS and WHOLE UNDERTAKING of HARRY F. ATKINS, Limited, in Liquidation, Machine Tools Manufacturers, Old Fletton, Peterborough.

Comprising:—
The FREEHOLD ENGINEERING WORKS, with the Fixed and Loose Plant and Machinery, Fixtures, Fittings and Office Furniture, Tools, Jigs, Templates, Stores, Stock-in-Trade, Goodwill, Patent Rights, Patterns and Drawings.

Tenders will be received up to 28th February, 1922, when they will be considered. The Receiver does not bind himself to accept the highest or any Tender.—Particulars and orders to view may be obtained from Messrs. DARKE, ROBSON & BATTY, 146, Bishopsgate, London, E.C. 2. T 337

TO FIRMS WANTING CONTRACTS.

Quotations are Required, for manufacture, in batches, of 250, on repetition lines, of lightly constructed brass hand-operated air pumps for low pressures, 2 in. bore by 15 in. stroke, with solid drawn tubular barrel, single disc valve and special two-way cock. The product is simple and easily made in any plain machine shop. Prices should be as if for a single lot of 250 although expected to be repeated from time to time.

The advertiser does not bind himself to accept the lowest or any quotation. Drawings of complete article showing all production data will be sent upon payment of fee of 12s. 6d., which will not be returned under any circumstances, to Mr. H. GEORGE HARLEY, Consulting and General Engineer, Grand Avenue, Camberley. T 551

APPOINTMENTS OPEN.

Works Manager for Firm of General Engineers in East London. Must be capable of estimating for and supervising repairs of all descriptions, as well as undertaking new work. Only thoroughly energetic man will be considered. Address, giving full particulars of experience, salary required, and copies of testimonials, T 534, Offices of ENGINEERING.

Machine Tools (Newcastle Area).—ALFRED HERBERT, LTD., Coventry, INVITE APPLICATIONS for the POSITION of MANAGER for their Newcastle Office. Applicants should be shop trained with thorough knowledge of modern methods of production. Preference will be given to those with knowledge of the district, selling experience and ability to control staff.—Reply with full particulars of age, training and experience. T 514

Machine Tool Sales.—Large firm of machine tool importers, with head office in Paris, REQUIRE the SERVICES of a GENTLEMAN to act as Sales Manager. Applicants should have workshop training, be familiar with modern methods of production, and have selling experience. Preference given to those who can speak and write both English and French.—Address, with full particulars.—T 495, Offices of ENGINEERING.

Works Manager Required for works near Sheffield, with practical knowledge of Press, Capstan and machine work generally, also of small assembly work. Applicants must have held similar position previously. It is essential that applicant should be a highly efficient organiser and have latest knowledge of modern methods of production. Full particulars, stating age, salary, etc., only considered.—Address, T 555, Offices of ENGINEERING.

Wanted.—British Gas Co. has VACANCIES for ENGINEER-PUPILS in Belgium. Commencing salary Frs. 3600 p.a.; good prospects; age 17-18; preference given to Public School Boys with knowledge of chemistry and French.—Apply in own handwriting, mentioning references, to

SECRETARY,
IMPERIAL CONTINENTAL GAS ASSOCIATION,
6, London Wall, E.C. 2. T 469

LITERATURE.

Modern Gas Works Practice. By ALWYNE MEADE, Assoc.M.Inst.C.E. Second edition, entirely re-written and greatly enlarged. London: Benn Brothers. Limited. 1921. [Price 55*s.*]

CONFRONTED with a volume of over 800 quarto pages, and one that has already run the gauntlet of technical criticism, by an author who is an expert in his science, and of which every chapter has been submitted to able colleagues trained in every branch of gas practice, there can be little for a reviewer to say beyond expressing his gratification at the completion of a work, conceived on generous lines and executed with care and discrimination. One reads such a book for instruction and not for criticism: to express approval may be impertinent and fulsome, to find oneself in disagreement is to distrust one's own judgment. The recital of a catalogue of the problems treated would be wearisome, but to discuss them with any thoroughness is impossible. Is one to approach such a work as detailing the production of the materials that support many other industries, and regarding coal gas as of second rate importance; as a civil engineer, who plans and erects the machinery for use in the carbonising industries; as an expert in illumination, who wants more light to enable him to continue the struggle with the electrician; or as one of those 7,000,000 consumers whose comfort and well-being are more or less dependent on the alertness and energy of those great corporations, who need 40,000 miles of street mains to bring their products to our doors with unfailing system and regularity? How so much is accomplished and how so many different purposes are served, efficiently and economically, is the tale that Mr. Meade unfolds. We do not see the successive steps that have led towards perfection. The great lessons were no doubt learnt in the days of small beginnings, and enterprise has grown with the opportunities for ministering to larger numbers, but the organisation must be supreme of its kind, that mechanically fulfils so many ends and with whose processes operative skill so rarely has need to interfere.

Of course, so large an industry has not been built up without Government control over the fiscal arrangements made between the gas companies and the public. In his scheme of picturing the gas development, the author in the first place, describes with some fullness the effects of recent Gas Regulation Acts. It may be doubted if the provisions of these Acts are fully apprehended by the public, the consumers, and the shareholders, and we therefore follow Mr. Meade's example, for these Acts are important and should be brought prominently forward. By the Gas Regulation Act, 1920, it is made obligatory to charge on a heat unit basis, and also to supply gas of 2 in. water pressure in mains and services of 2 in. diameter and upwards. Among other clauses, the adjustment of the standard or maximum price is made to meet the additional costs due to after-war conditions. The South Metropolitan Gas Act, 1920, touches us still more closely, for by its revolutionary clauses it abolishes the sliding scale on the old basis and substitutes an irreducible minimum of 5 per cent. for old capital and 6 per cent. for new money. The standard price per unit is 11*d.* per "therm," and the standard dividends can be paid even if the selling price exceeds this amount. But if the price is reduced, then an arrangement comes into force in which the consumer, the shareholder and the employee are interested. Three-fourths of the difference between the sum actually paid by the consumers and the sum the company would have received if the gas had been sold at the basic price is called "the consumers' share." The remaining quarter is then divided equally between the shareholders and the employees, apparently after a complicated plan depending in a great measure on the quantity of carbon bisulphide in the gas supplied. The arrangement seems rather involved, but doubtless we shall understand it better, after receiving a few of these unexpected rebates.

Not many may have the opportunity of choosing a site and laying out gas works, but those engaged in town planning or who are responsible for the conduct of municipal undertakings, will find here an able guide and a wealth of information, with the main portion of which it will be prudent to be acquainted. They will learn much concerning the choice of a site, the handling of materials in bulk, the strengthening of foundations, the probable cost of the erection of gas plant, of the maintenance of main and services, and what the promotion of gas works entails. Two facts will perhaps cause some surprise; one is that in preparing a scheme for 15,000 consumers, it is desirable to supply 6,500 "ordinary" and 8,500 slot meters, showing the eagerness with which the poorer classes have welcomed this method of supplying them with gas. The second is that the works designed to supply 15,000,000 cub. ft. per annum would absorb approximately 4*s.* per 1,000 cub. ft. for permanent and floating capital costs, and if 50,000,000 were supplied some 3*s.* per 1,000 would be required. These figures refer to post-war prices, on which Mr. Meade has based his estimates as accurately as possible, and exceed approximately three-fold, the amount of ten years ago. Fortunately, most gas undertakings had their origin in a time of cheap money, but extensions necessitated by lapse of time will prove costly ventures, and growing towns, garden villages and outlying suburbs are likely to be faced with heavy and unprecedented expenditure in providing artificial light. Electricity may here find opportunity for intelligent competition.

When the works are sufficiently far advanced to admit the erection of retorts, the details to be settled by the gas technologist are of a very complicated character. Should the retorts be horizontal or vertical or inclined? The last may be dismissed as obsolete, the idea that the retort should make an angle of 32 deg. with the horizontal—the theoretical angle of repose of coal—has no practical support. The horizontal retort is generally adopted in this country, and if this precedent be followed there is again the choice of three types of setting: Direct-firing, semi-gaseous, and gaseous fired. The first though still in use may be dismissed on the score of extravagance and the difficulty of controlling the air supply, but among the more modern forms a choice has to be made between generator settings, regenerator settings, and those heated by outside producers of various types. The final selection is not simple, and we can only recommend the perplexed and interested authorities to master some 200 pages of this excellent work, in which the author discusses the various alternatives. The whole theory of combustion has to be weighed, the price for which coke can be sold locally is an important factor, the additional outlay of capital required for erecting the more expensive setting may turn the balance. The cost of extra labour and of supervision is only one of the many items, which it is necessary to take into consideration before making a decision. Hence the necessity for a competent guide.

The choice, as the improvement of refractories, is a subject that naturally attracts attention, for in a gas works, retorts not only have to withstand great heats, but are submitted to considerable fluctuations in temperature. Chemical reaction also works destructively, moist air carrying a salt vapour has a highly corrosive action on fireclay bricks. A good silica brick appears to offer the greatest resistance especially at the lower temperatures, such as are met with in coke ovens. The accurate measurement and control of temperature is likely to work economically in gas-making. Pyrometers of robust type are being substituted for the human eye, but the degree of accuracy required is not great, and skilled workmen have acquired such nicety of perception that their judgment is fairly trustworthy. For industrial pyrometers, the author is inclined to favour the base metal thermoelectric couple, such as iron-constantin, on the ground that these pyrometers by developing a large E.M.F. permit the use of robust construction. Apparently, any device that tended to eliminate guess work, and register temperature with a small limit of error would increase the efficiency of operation.

The mechanical handling of materials and the employment of electric energy for operating gas plant have, of course, a wider application than in gas works, but it would appear from a statement made here, that the utmost advantage has been taken of mechanical appliances to reduce manual labour. In 1893–7 about 20 men were required to produce 1,000,000 cub. ft. of gas per diem: to-day stimulated "by recent incidents in the labour world," the number is only four. It must be understood that the saving is by no means so great as it appears on paper, for the introduction of labour-saving plant is often a costly luxury. At the present time, it is calculated that the saving of one man's labour warrants an expenditure of 1,400*l.* on capital outlay, or 1,300*l.* on machinery. This is on the basis of paying 20*d.* per hour for a 47-hour week. Though in large works such expenditure might be warranted, it is doubtful whether it would work economically in small. Of course, the man would become available and productive in some other direction, and the State as a whole would be benefited to the extent of his labour, but in these days of huge unemployment, it is doubtful if such an argument would carry much weight.

The qualities that distinguish a good gas-making coal, and the nature of the primary and secondary reactions associated with the carbonisation of coal are attractive subjects to dwell upon, as there are still many problems that have not yet been completely solved, but we can do no more than congratulate the author on the lucidity with which he has presented a highly complex subject, bristling with many difficulties, theoretical and technical. The next chapter is devoted to the condensation of coal gas or the reduction of gas to normal temperature, with the removal of those substances which are not permanent gases at such temperatures. Atmospheric condensers are described, but naturally water condensers are preferred in modern practice. There is another substance in warm crude gas, however, naphthalene, which is apt to give much trouble. Modern methods of carbonisation have diminished this annoyance, but the author cannot promise a satisfactory solution; for the method of treatment at one works may prove useless at another. This uncertainty may be traced to the fact that naphthalene is not formed as a direct distillation from the coal itself, but is the result of secondary influences, which affect the gas during its passage from the retort, but once formed naphthalene is found to possess great stability and cannot be decomposed by simple means. The usual methods of dealing with it are described, but entire elimination is neither promised nor expected, the aim being to reduce the amount so much in quantity that it can be carried by the gas without deposition. The other impurities or additional products found in the gas at this early stage, include suspended tarry matter, sulphuretted hydrogen, carbon disulphide and carbon dioxide, hydrocyanic acid, and ammonia. A very considerable percentage of the last is removed in preliminary washing, and the solution formed reacts on the acid impurities. Some of the other by-products, small in amount, are not removed and the CO_2 is regarded as an inert diluent, of which the Board of Trade can limit the percentage, if seen fit. The most interesting of the remainder of the products is the cyanogen content, since it forms the main factor in the treatment of gold-bearing rocks and quartz for the recovery of gold; The amount of output from British gas works is about 5,000 tons, and might be much more but the cyanogen is recoverable in such small quantities that a ton of coal yields only about 1½ lb., and consequently it is only the larger gas works that find the recovery sufficiently profitable. But because of the fouling effect of cyanogen in gasholder water, the corrosion of plates, and in deteriorating the purifying material now in use in the dry process of purification, some attempt is made to reduce the quantity, generally by means of lime purifiers. In this latter stage, several processes are described that will interest the gas engineer, but the details are necessarily omitted here.

A chapter is rightly devoted to water gas, for it is still an auxiliary to coal gas and is employed by a large number of gas undertakings as a means of providing for increase of business, and fluctuations in demand, such as heavy fog might occasion. A water-gas plant may be started from cold in 3 hours, whereas a retort bench requires three days. But while originally adopted as an enriching

medium on account of its cheapness, water gas no longer possesses this advantage. The price of oil has rendered its use prohibitive, and further enrichment is less esteemed owing to the introduction of a calorific standard. But many points can still be urged in its favour. The production of carburetted water gas requires a smaller amount of manual work than machine-charged horizontal retorts, and in these days of labour upheaval this is a point not to be overlooked. The sulphur impurities are low, and the trouble with naphthalene deposits are said to give less trouble. Also by the large employment of coke, the steady manufacture of water gas exercises some control over the coke market. Industrially, "blue" water gas on account of its exceedingly high flame temperature can be usefully employed in the welding of plates and heating of furnaces. But in any case since 24,000,000,000 cub. ft., about one-tenth of the total gas production, are generated annually, the theory and methods of procedure deserve consideration in a book of this kind.

In the early days when "blue" water gas was on its trial, it was usual to gasify the volatile material, leaving behind the carbon and ash. This residue on being treated with steam yielded the water gas, which, at a later stage, could be mixed with the product from the retorts, but two distinct processes and two separate plants were needed. Under pressure for economic production, plans were suggested for the construction of a special plant in which the complete gasification of coal or the combination of the two processes could be carried out simultaneously. The substitution of the thermal unit in place of candle-power illumination has given an impetus to this method of manufacture, for the most efficient method of gas production must be regarded as that which yields the cheapest British thermal unit. As a matter of figures, the advantage is decidedly on the side of complete gasification in one process, but the amount of tar and ammonia derived from this improved process does not compare favourably with that derived by the older methods. The explanation is fairly simple, and the costs of production by the two operations are worked out in detail and accuracy, but like so much in this book that invites discussion, we can only say that precise and convincing information will be found in this volume. The publishers quote the verdict of a contemporary on the first edition of this work, and we can heartily endorse the judgment, that "Mr. Meade has dealt with his matter in a manner as judicious as its substance is full. He seems not to have missed a point of modern gas-works practice, and the book is emphatically one which no gas engineer can afford to be without."

Kritik des Zeitstudienverfahrens. By I. M. Witte. Berlin: Julius Springer. [Price 15 marks.]

The literature on the Taylor system and on motion studies of operators at work has grown to such an extent, even in Germany, that Mr. Witte deems it advisable to justify his "Critique of the Time-Study Method" as an Inquiry into the Causes which lead to Non-Success of Times Study, undertaken for the purposes of clearing up misunderstandings. He writes as a pupil of Mr. Frank B. Gilbreth, under whom he made his first practical studies of the system before the war. His aim is the eudemonistic optimum in the workshop. He is convinced that there must be one best way of performing a certain operation with the aid of the one best tool, in order to obtain that optimum; suitable kinematograph time studies will reveal that one best *modus operandi*, upon which we can base rate setting and rules of management. But we must watch the best operator by the best methods of observation. Reliance upon stop watches and average workers account for a good deal of the prejudice still existing against the Principles of Scientific Management and for some of the apparent failures of the system in practice. That, briefly, seems to be the essence of Mr. Witte's arguments in this pamphlet of 70 pages.

We are sceptical as to these single superlatives, the reiterated "one best." The best method and the best man or expert might be thought acceptable by analogy to the ideal gas. But the analogy would not hold. The mathematical physicist deduces his gas laws for the perfect gas, though his laboratory does not know this gas. He assumes to know, at any rate, that, in the absence of all impurities and disturbing factors, one sample of nitrogen will behave exactly like another, that there is no individual or personal factor to reckon with, and that this applies also to a simple mechanism. In that sense every gas, as well as every mechanism, is normal, as long as we can quantitatively explain deviations from normality. In that same strict sense, however, the normal human being does not exist, and it is illogical to speak of the "best" man. There may not be any man fit to serve as model in a particular workshop at all. The best man selected may owe his superiority to exceptional skill or strength, to his being left-handed—some parents still check any tendency of a child to use his two hands indiscriminately—to some nervous or muscular peculiarity which some medical man would consider a defect, to keen sight or to astigmatism. The one best method is equally illusory; to insist upon it would mean stereotyping mistakes. Workers naturally resent being judged by what they might regard as an unfair standard. Nobody works so well when under supervision—visible or suspected—as he works when quite at his ease and unrestricted. Mr. Witte is anxious to avoid fatigue of body and mind, and he regrets that some Taylorists do not pay sufficient heed to that point. It is undoubtedly one of the chief legitimate causes of the unpopularity of Taylorism. We must not reduce a man to a machine which may some day break down irreparably.

We do not wish to press these arguments which do not affect enlightened Taylorism. Nor do we quarrel with Mr. Witte when he criticises the ways of some of those who would substitute the "average" man for the "best" man, and who do not consistently adhere to their own doctrines. In a minor measure he classes Taylor himself with these Taylorists. In the "Time Studies as a Basis for Rate Setting," which were published by Mr. Dwight V. Merrick in 1919, after Taylor's death, but written partly under Taylor's supervision, Taylor—or Merrick—seems to shift his ground. The principal aim is no longer the determination of the best method of working, but "the means to attain the fundamental objects in manufacturing of high wages and low labour cost." Merrick and others with him take averages by disregarding extreme data and by making use only of apparently normal figures. To a certain degree that is generally done in statistical compilations, and we are justified in rejecting a figure when we know that the machine or the hand was not functioning normally at the moment. But to rule out low and high values as abnormal when trying to arrive at an average rate in cases where the component terms are yet unknown is certainly not scientific, especially so when the averages deduced by arbitrary selection are finally given to

REINFORCED CONCRETE RESERVOIR AT WALKERBURN.

CONSTRUCTED TO THE DESIGNS OF CONSIDÈRE CONSTRUCTION CO., LTD., LONDON.

(*For Description, see opposite Page.*)

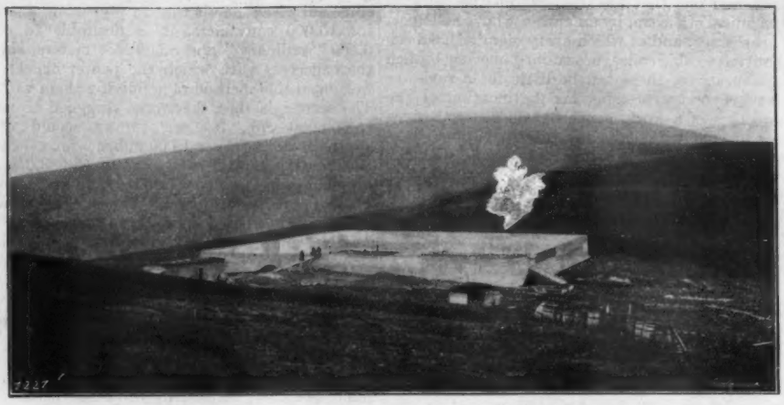


Fig. 11. General View of Reservoir on Kirnie Hill.

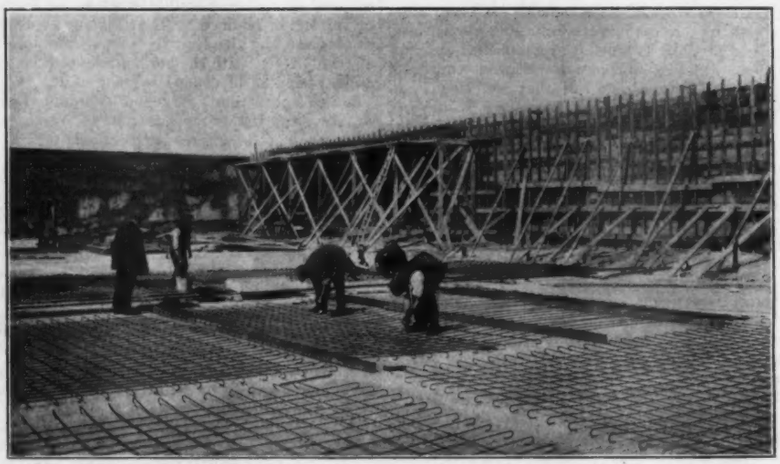


Fig. 12. Interior of Reservoir; Reinforcement of the Floor.

REINFORCED CONCRETE RESERVOIR AT WALKERBURN.

CONSTRUCTED TO THE DESIGNS OF CONSIDÈRE CONSTRUCTION CO., LTD., LONDON.

WALKERBURN RESERVOIR. VIEW SHEWING TYPICAL REINFORCEMENT.

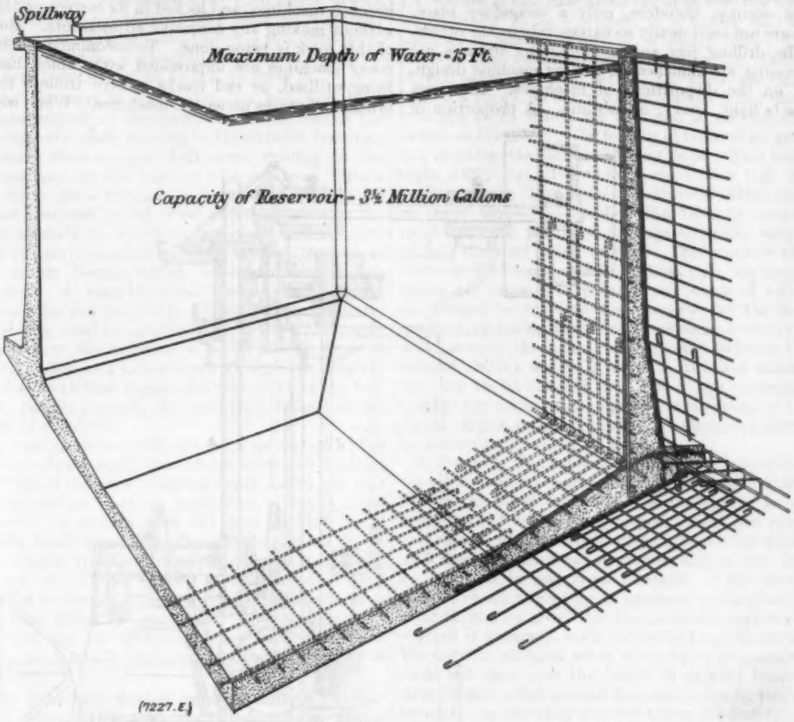


FIG. 13.

the fourth decimal, though the observations were made to the first decimal only and by means of stop watches! Taylor was quite aware that his stop-watch observations were defective. Some of his adherents are not troubled by that consideration, and they lose sight of the principle. To them it is quite immaterial how and with what the work is done, provided the task be accomplished expeditiously and economically. Critics who protest that Taylorists have little right to speak of "scientific" principles of management might do well first to study what they criticise and to reform their own unscientific methods.

Mr. Witte's practical experience of Taylorism is limited to what he saw in America. He cannot tell the reader how the system is working in Germany. He is not aware that motion studies have actually been adopted, and we must assume that the numerous recent German books on the subject are mostly critical discussions of American opinions and practice, still written partly in ignorance of, or without due appreciation, of the superior methods of Gilbreth. There is certainly no lack of interest; but the labour difficulties on the Continent are not propitious to the adoption of innovations.

BOOKS RECEIVED.

Concrete and Reinforced Concrete. By W. Noble Twelvetrees, M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 3s. net.]

Ingenieur-Mathematik. Lehrbuch der höheren Mathematik für die technischen Berufe. Vol. II. Von Dr. Ing Dr. Phil Heinz Egerer. Berlin: Julius Springer. [Price 528 marks.]

The Manufacture of Cane Sugar. By Llewellyn Jones, M.I.E.S., and Frederic I. Scard, F.I.C. Second Edition. Revised. London: Duckworth and Co. [Price 25s. net.]

Distillation Principles and Processes. By SYDNEY YOUNG, M.A., D.Sc., F.R.S., assisted by others. London: Macmillan and Co., Limited. [Price 40s. net.]

Lektrick Lighting Connections. With Introductory and Explanatory Notes. By GUS. L. LUNDBERG, M.I.E.E., and W. PERREN MAYCOCK, M.I.E.E. Seventh edition, thoroughly revised. London: A. P. Lundberg and Sons. [Price 1s. net.]

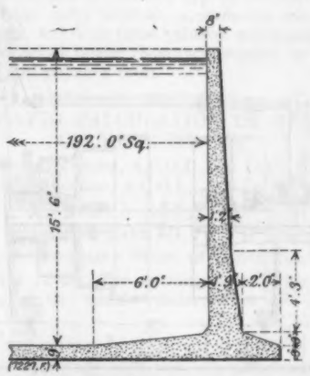


FIG. 14.

THE WALKERBURN WATER POWER MECHANICAL STORAGE INSTALLATION.

(*Concluded from page* 193.)

REFERRING next to the water storage, a view of the reservoir situated on the top of Kirnie Hill is given in Fig. 11, page 218. This reservoir has a capacity of 3½ million gallons. The pipe line between the station and the reservoir is laid underground. The upper section between the surge tank and the reservoir is nearly level and is of 12 in. diameter. The portion on the hill side is 9 in. diameter.

In calculating the reservoir capacity required, it was reckoned that during the week end and nights the total which the pumps could deliver would be a little less than 3 million gallons, which, if the Pelton wheel were run at full capacity for the whole working time during the week, would mean a deficit at the end of it. The Pelton wheel, however, does not work on full load the whole time, and merely meets the fluctuating demand for power over and above the constant amount met by the low-pressure turbines. To meet the expected deficiency and have a reserve for contingencies the reservoir was made, as we have stated, with a capacity of 3½ million gallons.

By the courtesy of the Considère Construction Company, Limited, of 72, Victoria-street, Westminster, S.W.1, we are able to give details of this part of the work, this company having been responsible for the design of the reinforced concrete work, the reservoir being constructed on the system with which their name is associated. Fig. 11 shows the reservoir and the drawings, Figs. 13 and 14, give details of the reinforcement and wall sections. A view of the interior is given in Fig. 12, taken during the process of laying the floor slab, which was introduced on account of the possibility of the ground not being watertight.

The reservor is 192 ft. square by 15 ft. 6 in. deep. The main part of the floor slab is 9 in. thick and contains towards its upper surface a light reinforcement. At a distance of 6 ft. from the inner face of the wall the thickness increases till a depth of 18 in. is reached at the wall itself. The thickness of the walls varies from 8 in. at the top to 21 in. at the bottom. They are heavily reinforced, as shown in Fig. 13, the reinforcement being well tied into the floor. Near the foot the outside batter of the wall increases to provide against the increased bending moment at that part. The actual taper is from 8 in. width to 14 in. width in the upper 10 ft. 6 in., while below that level it increases, so that a further 7 in. is added to the width of the section in the lower 5 ft. 9 in. As will be noticed from Fig. 14, an outside toe is run round the whole tank. This extends out a distance of 2 ft. and decreases in thickness from 18 in. at the wall to 9 in. at the edge. No other foundation for the side walls was provided than the thickened floor section. The tensile stress in the vertical rods of the wall was limited to 6½ tons per square inch, with a view to minimising the possibility of surface cracks taking place. Concrete of a mixture of 1 : 2 : 4 was used, and great care was exercised in the selection, grading and mixture. During the recent test no leakage or sweating in any part of the reservoir was observed. This is particularly satisfactory, in view of the very difficult conditions obtaining at this altitude, 1,497 ft. above sea-level, during construction. The construction of the reservoir required over 3,000 tons of aggregate, 400 tons of cement and about 100 tons of reinforcing bars, all of which material was conveyed to the site by means of a cable way.

The contractors for the construction work were Messrs. Melville, Dundas and Whitson, Limited, of 93, West George-street, Glasgow. Mr. J. Sharp, M.I.Mech.E., of Glasgow, acted as consulting engineer during the construction and erection of the whole undertaking. The plant has now been in successful operation for several weeks.

RECENT MACHINE TOOL DEVELOPMENTS.—No. XXV.

By JOSEPH HORNER.

AFTER the more efficient performances of drilling machines which are guaranteed by many manufacturers, the question of the multiplication of spindles arises. The retention of single-spindle machines is, as a rule, incompatible with production on a large scale, unless the machines are ranged in series, in gangs, suitably for a particular group of operations, in which circumstances it may be preferred to the employment of the regular gang machines, with spindles running at uniform speeds. The choice depends on the character of the work, and the attendance available. Frequently the cluster spindle machines should have preference. Many of the problems that now involve the weighty consideration of alternatives have arisen in connection with the mass production of automobiles, and of aeroplanes. In both, the separate elements are numerous, they are required in large quantities, so that the same machines may be engaged in their production for many months consecutively, without any change in their equipment.

Here also the employment of fixtures to hold the articles, and of jigs to locate and control the tools exercise a considerable influence over the selection of machines. The fixture enables work to be

transferred between different machines, by avoiding the task of resetting and clamping directly on tables, and the jig ensures that holes, &c., will be centred all alike, though produced under different machines, handled by several attendants.

Again, the operations of the drilling machines embrace a wider scope than they did formerly, since much of the work that was once transferred to the lathe, the screwing machine, and even to the vice is commonly done from the drilling spindle such work as reaming, facing, bossing, arboring, tapping. Hence, when considering how best to utilise the drilling machine, these subsequent and related operations have to be included, and often provided for. These facts explain the reasons of the extensive variations in the designs of drilling machines, and their numerous adaptations, and equipments, made with the object of concentrating and intensifying their output. These chiefly concern the multiple spindle machines, though similar results are secured for some classes of work by the disposition of single-spindle machines in gangs.

The question of selection is answered in two ways. Assuming single pieces are to be drilled, and reamered, &c., and in large quantities, they are either transferred between single-spindle machines, arranged in gangs, each in charge of a separate attendant, or in multi-spindle machines with one attendant each. The latter should therefore apparently have preference. The question of weight arises here. If a piece is massive, or if it is loaded in a heavy fixture, it is better not to transport it between single machines, but to perform all the operations under one, at one setting.

In some cases, having a fixture on the machine table, under a multi-spindle drill, the pieces under one set of spindles are being removed and reloaded while work is being done by the other set. Or separate fixtures may be used, thus effecting an economy of time which is adopted in some milling and vertical-spindle grinding machines.

Many multi-spindle machines are now built in which the spindle speeds can be varied to suit the drilling of small and large holes, and the speeds suitable for reaming, tapping, arboring. The majority do not include this provision, which is a recent one, consequent on the increasing specialisation of functions. But a fair number of attachments are now marketed, for use on the ordinary machines, in the form of multiple-spindle heads, with provisions for different spindle heads.

Multi-spindle machines fall under two groups, those having the spindles disposed lineally—descendants of the forms used by boiler makers, and platers, now built in a wide range of designs; and those with cluster, or grouped spindles, a later development, manufactured by several firms in many modified forms. These are used for drilling crank cases, the holes for cylinder studs, those for frames, transmission cases, and other parts where large numbers of holes have to be drilled in circles, rectangles, or in irregular dispositions. A feature which renders these of so great general utility is the fact that they can be adjusted in different patterns, and to different centres as required. The number of spindles may range up to 20. But it is practicable to drill holes much more closely than the spindle centres, by doing the work in relays. The general scheme of these machines has not been much modified from the earlier forms, but improvements and extensions have been made in details.

The cluster spindle designs fill a place that bears broadly the same relation to the work of the radial machines that the gang drills do to the single-spindle types. In the radial machines, the drill, reamer, or tap is brought to each hole in succession by the movements of the spindle head and the arm. But the work is slow when holes are numerous, notwithstanding that these machines have been the subject of many improvements that make for higher efficiency, including often the provision of two spindles. But they are wholly outclassed when holes are numerous, and the work is repetitive. In some highly specialised designs the centres are fixed to suit one product alone that is being regularly repeated.

The drilling machines equipped with turrets fulfil similar functions to the others. Though only one spindle is in operation at one time, each spindle has its most suitable speed and feed. These machines therefore bear similar relations to the common drills that the turret lathes do to the ordinary designs. Their sphere, however, is that of alternatives to the gang, rather than to the cluster designs. They occupy, therefore, only a secondary place, and are not used nearly so extensively as the others.

The drilling jigs and work-holding fixtures are exercising an influence on drilling machine design, and on the dispositions of machines. The work done is light, heavy, or medium. A proportion of each may be jigged without any clamping on tables. A large quantity must be gripped in a fixture, because irregular, unsteady outlines do not permit of standing them on a table; and packing up and clamping to a table are inadmissable in many cases, because of the large amount of time they occupy, and the want of uniformity of results in repetitive work. The ideal arrangement for small articles, easily handled, is to enclose them in a jig fixture, which may hold one or more, depending on dimensions; which can be transferred between machines, of the single-spindle type, or be dealt with entirely under the multi-spindles of a single machine. Only small loads can be carried about from machine to machine, but these are a large proportion of work done. If those of large dimensions involve transport, this must be accomplished by methods that are both rapid and accurate. Here the cluster spindle machines, when provided with variable speeds show to great advantage. The heaviest work can be done under them, and often as many different operations as are desired. The work is held in a fixture, and jig plates can be changed if need be for two operations on the same hole, as drilling and reaming, or bushings may be changed. If boring and drilling are required, or drilling and milling, the heavy fixture with its load can be transported on rails between machines, and locked in its correct position without making any tentative adjustments. Much of this work is being done. To accommodate this, many machines are unprovided with tables, bases being utilised, or rail tracks receive trolleys that bring the fixtures under the machines. When work has to be done from faces situated at different angles, the changes in position are provided for by the design and construction of the fixture, made to swivel or cant as required. And if the output is very large the fixtures are duplicated, one being on the machine while the other is loading.

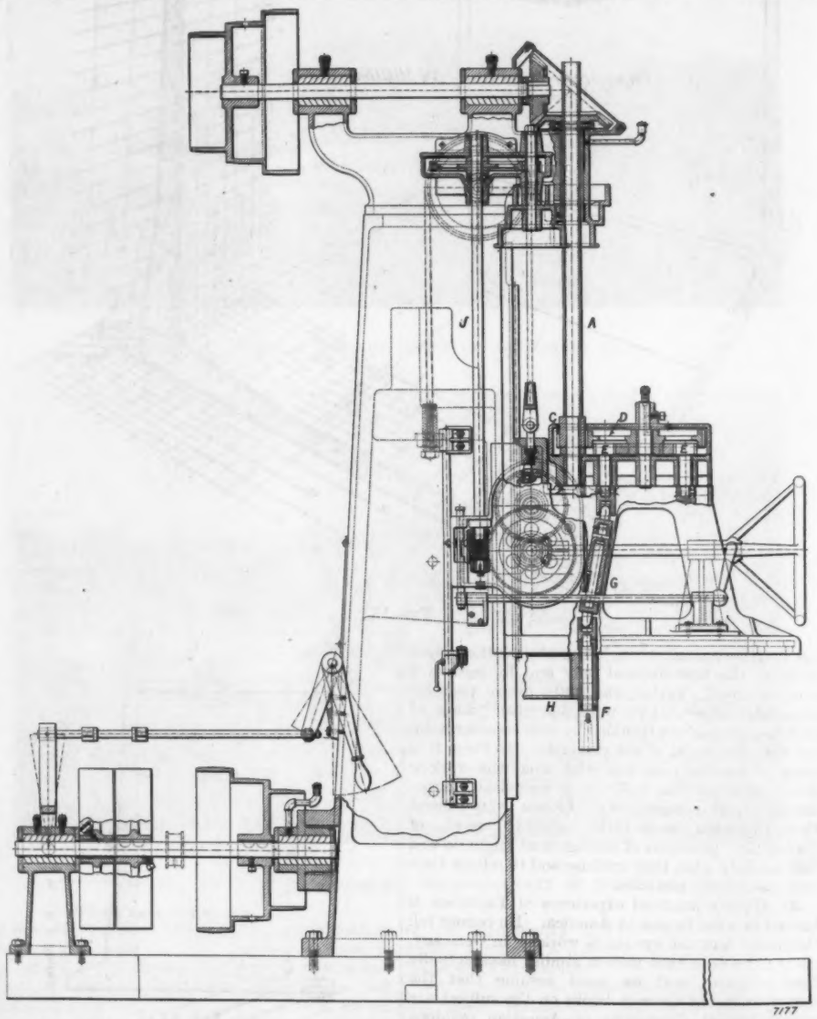


Fig. 500. Multiple Drilling Machine; Messrs. Bausch Machine Tool Company, Springfield, Mass., U.S.A.

Multiple spindles are gear-driven, the whole of the mechanism being carried compactly in a head that slides vertically on the face of the machine column, and is counterbalanced with a weight within the column. The upper part of the head is an enclosed case containing the gears, which are all driven primarily from a main vertical shaft, having speed changes variouly effected. A spur pinion on the main shaft drives to gears on short spindles, from which connection is made to the drilling spindles through universal joints. A telescopic tube has a joint at each end, which permits of shifting each spindle along its own radius bar at different radii from minimum to maximum. Each spindle runs in a sleeve which can be adjusted separately

for each separate drill. The details of the head fittings differ considerably.

A single example of one of these machines by the Baush Machine Tool Company, of Springfield, Mass, U.S.A., is shown by Fig. 500, on page 220. The head, as in other machines by the firm, is a separate unit, interchangeable with three others, with different capacities. The machine will carry twenty ¼-in., sixteen ⅜-in., twelve ½ in., eight ¾-in., or six 1-in. drills, working in cast-iron or steel. It requires from 10-h.p. to 15-h.p. to drive it.

The machine is driven by the fast and loose pulleys carried on the baseplate at the rear of the column—the shaft, running in Hyatt roller bearings, carries a three-stepped belt cone, driving to the reverse cone at the head of the column. Thence the drive goes through a horizontal shaft, with Hyatt bearings, to the bevel and spur gears on the vertical shaft A, which is doubly splined to move with the movements of the head through the boss of the crown bevel, which is supported on ball bearings. A variable-speed motor may be substituted for the belt drive on cones. The mass of the sliding head is counterbalanced with the weight seen within the column, a cable passing from it over a pulley to a safety catch B, which is pivoted, and has teeth that engage with the teeth of the feed rack, and so prevent the head from falling in the event of accident.

A head is shown with its gears in section. The doubly-splined shaft that slides vertically through the bore of the crown driving bevel carries the first driving pinion C at its lower end. This is heat-treated. It meshes with the gear D that has a spindle head keyed to its boss below, which drives the various spindle pinions E, ranged in a circle around it. These pinions actuate the drilling spindles F, through the telescopic tubes G, with their universal joints at each end. The spindles are adjusted and set with clamping straps along their radial arms to any locations within the capacity of the head.

The feeds are effected by rack and pinion, outlined, being driven from the belt feed cones at the upper part of the machine, through the vertical shaft J, to the worm, and spur gears below, to the rack pinion. A knock-out is shown to the worm drive, actuated by the feed-trip collars adjustable on a rod. The power feed is put in with a lever, and the feeds are changed with another. A pilot handle wheel is provided for the hand travel of the head. The feeds are four in number, viz., 0·003 in., 0·005 in., 0·007 in., and 0·1 in. feed of drill per revolution.

The head has a traverse of 26 in. on the column. The greatest distance from the spindles to the bed is 42 in., the least distance is 16 in. This particular machine can be equipped with either one of the following heads—the size in each representing the maximum drilling lay-out:—

Sixteen inches round, with a capacity for six 2-in., eight 1¾-in., or twelve 1½-in. spindles; 20-in. round, with capacity for six 2-in., eight 1¾-in., twelve 1½-in., or sixteen 1¼-in. spindles; 24-in. round, with capacity for six 2-in., eight 1¾ in., twelve 1½-in., or sixteen 1¼-in. spindles; 16-in. by 30-in. rectangular, with capacity for twelve 1¼-in., sixteen 1¼-in., or twenty ¾-in. spindles.

Auxiliary multiple spindles are fitted to machines. These are gear-driven like those in the example. But there is one design in which the spindles are revolved without gears by an eccentric and crank motion. Its casing is attached to the spindle sleeve of the machine. A taper shank fits in the standard tapered nose, and has a crank on its lower end which, by the rotation of the spindle imparts an eccentric movement to a driving plate that rotates the drill spindles, the upper ends of which are formed as cranks fitting in the driving plate. All the revolving parts are bushed, and have radial ball races.

The cluster spindle design includes horizontal dispositions of the spindles and combinations of both in one machine. In some cases three heads will be in simultaneous operation. It is a marvellous development. There seems hardly a limit to the unconventional designs of machines. One of these relates to the drilling of deep holes, which present difficulties consequent on the chips choking the holes. This usually entails occasional withdrawal of the drill to clear out the chips. When several spindles are in operation this becomes more objectionable than it is on single-spindle machines. So the relations are inverted, the drills being located below the work, and stationary, while the work is gripped in a chuck and rotated, and fed down over them. The fixture in this case holds the drill, and any tools which follow it, as a reamer, or a hollow mill for turning, a facing cutter, or screwing dies. The principle has received applications in the tooling of shell cases, and shell parts. The shell case being held in a chuck on the machine spindle is fed down over the tools, which are mounted in an indexing fixture on the table. The feeding of tables is adopted in a considerable number of gang drills. This has a slight additional advantage in some cases that the loading can be done better on lowered tables than on those which are fixed. The table is counter weighted, with provision for regulating the weight to suit the load being carried. This method also lends itself to economies in feeding, since the movements are imparted by cams, the edges of which are shaped to regulate the character of the feed required, including a more rapid movement when the drill has to go through a clear gap, and so lessen the time of cutting wind. A dwell is included when a face has to be cleaned up. For tough materials, notches are cut in cams to permit of breaking up the chips. Quick return is provided. Cams are driven by power, or operated by hand.

In bringing this series of articles to a conclusion, the writer becomes impressed by the knowledge that the treatment of the subject is inadequate to its immense and evergrowing importance. Not many years since, machine tools were built in a few types, with details worked out in simple, and as they now appear to us, in very crude fashions. Their successors are characterised by an immense multiplication of parts, and by provisions that make for superlative degrees of accuracy, with corresponding efficiencies. The time is at hand when the subject of machine tools will pass into the hands of experts familiar with certain great groups that have closely related aspects. In this they will but follow the lead of the manufacturers who now concentrate their energies on the production of some few typical machine tools of one kind only, built in a moderate range of dimensions, and with those valuable provisions and variations which render them indispensable to those who have to use such tools.

THE RAPID CALCULATION OF FERRO-CONCRETE BEAMS.

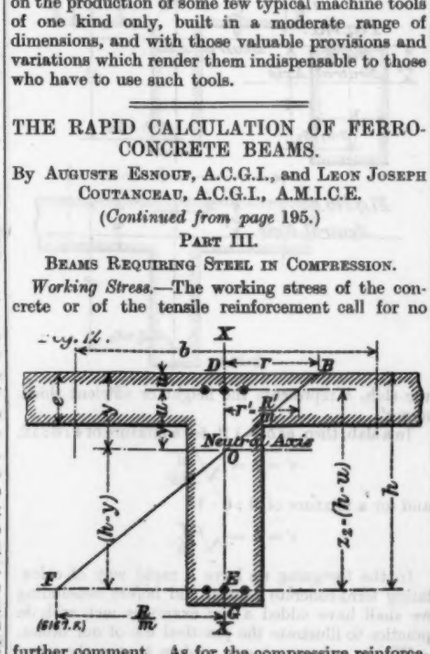
By AUGUSTE ESNOUF, A.C.G.I., and LEON JOSEPH COUTANCEAU, A.C.G.I., A.M.I.C.E.

(*Continued from page* 195.)

PART III.

BEAMS REQUIRING STEEL IN COMPRESSION.

Working Stress.—The working stress of the concrete or of the tensile reinforcement call for no further comment. As for the compressive reinforcement, its working stress R^1 will be such that:



$$R^1 = m\,r^1 = m\,r\left(\frac{y-u}{y}\right) \text{ (Fig. 12)} \quad . \quad \text{(VII)}$$

It is evident that R^1 is always small compared with R; the limit towards which its value tends without ever reaching it is $R' = m\,r$ (for then, see Fig. 9, page 194 *ante*, $u = o$ or $y = \infty$).

It follows then that, by using compressive reinforcement, waste is entailed in as much as the steel is made to work at a stress much below the normal permissible stress.

Consequently, compressive reinforcement must be used only when absolutely unavoidable, in such cases when the maximum height of the beam is rigidly fixed, and is insufficient to allow of tensile reinforcement alone to be used even when a rich mixture has been chosen.

Moreover, it will be always wise to use with beams requiring steel in compression, the richest mixture, so as to let the steel work at its most advantageous stress, the value of R^1 varying directly with that of r.

Moment of Resistance.—This moment of resistance $\mathfrak{M}$ can be split up into two elements:—

1. The moment of resistance $\mathfrak{M}_1$ of a similar beam, but without steel in compression and with its normal tensile reinforcement; we have already seen how to determine $\mathfrak{M}_1$, and also the cross-section S_1 of the steel.

2. The moment of resistance $\mathfrak{M}_2$ (where $\mathfrak{M}_2 = \mathfrak{M} - \mathfrak{M}_1$) of the compressive reinforcement, and additional tensile reinforcement to balance same.

If S' = cross-section of the compressive reinforcement, and S_2 = cross-section of additional tensile reinforcement, we have: $R' \,.\, S' = R \,.\, S_2$.

The lever arm Z_2, see Fig. 9, or distance between the points of application of those forces, is $(h - u)$.

Then: $\mathfrak{M}_2 = \mathfrak{M} - \mathfrak{M}_1 = \mathfrak{M} - M_1 = R' \,.\, S'(h-u) = R \,.\, S_2\,(h-u)$, and whence we get:

$$S_2 = \frac{\mathfrak{M}_2}{R\,(h-u)} \quad . \quad . \quad . \quad \text{(VIII)}$$

Simplifying from equation (7):

$$S' = \frac{\mathfrak{M}_2 \,.\, y}{m\,r\,(y-u)\,.\,(h-u)} \quad . \quad . \quad \text{(IX)}$$

It is to be noticed that in homologous beams, *i.e.*, beams in which the ratios $u : y : h$ are the same for all of them, R′ will be constant; the same is true for the ratio $\frac{Z_2}{h}$. If we confine ourselves, as already suggested, to using for beams requiring steel in compression, only the richest mixture of concrete, we will have in all calculations a constant value for r, and consequently for $\frac{h}{y}$. (R; and M being also constant).

Suppose, then, we employ what we call the mixture 4 : 6 : 12, where we take $r = 700$ lb./in.², $m = 12$ and R = 15,624 lb./in.², we will have:

Since

$$y = \frac{m\,r}{R + m\,r} \,.\, h, \text{ we have } \frac{h}{y} = 2.86$$

Let us call as before:

$$\frac{h}{y} = i_1 \text{ and let } \frac{h}{u} = C$$

Then from (IX)

$$S' = \frac{\mathfrak{M}_2}{h} \,.\, \frac{C^2}{m\,r\,(C-1)\,(C-i_1)} \quad . \quad \text{(X)}$$

$$S_2 = \frac{\mathfrak{M}_2}{h} \,.\, \frac{C}{R\,(C-i)} \quad . \quad . \quad \text{(XI)}$$

and

$$R' = m\,r' = m\,r\left(1 - \frac{i_1}{C}\right). \quad . \quad \text{(XII)}$$

From (X) and (XI) we have:

$$S' = k' \,.\, \frac{\mathfrak{M}_2}{h} \text{ where } k' = \frac{C^2}{m\,r\,(C-1)\,(C-i_1)}$$

and

$$S_2 = k_2 \,.\, \frac{\mathfrak{M}_2}{h} \text{ where } k_2 = \frac{C}{R\,(C-1)}$$

By taking different values of $C = \frac{h}{u}$, it is easy to calculate the corresponding values of R′ and also the constants k' and k_2 which, when multiplied by $\frac{\mathfrak{M}_2}{h}$ will give the values of S^1 and S_2 in equations (X) and (XI).

Table III gives the values of R′ and k_2 and k' for corresponding values of $\frac{h}{u}$. These are also expressed as graphs in Fig. 13.

It will be noticed in Table III, that considering the most favourable case, the limit of a beam where the ratio $\frac{h}{u} = \infty$; $k_2 = 0{\cdot}000768$ and $k' =$

0·001429, so that $k_2 + k' = 0·002197$ or $S_2 + S' = 0·002197 \frac{M_2}{h}$.

On the other hand, in the most disadvantageous case of a beam without compressive reinforcement, when $i_1 = \frac{h}{y} = 2·86$; $k_1 = 0·0008694$ and $S_1 = 0·0008694 \frac{M_1}{h}$, so that if:

$$M_2 = M_1, \; S_2 + S' = 2.53 \; S_1$$

and

$$S_2 + S' + S_1 = 3.53 \; S_1,$$

which means that to double by means of compressive reinforcement the normal moment of resistance of a beam not having steel in compression the cost of steel will be increased in the proportion of 3·53 to 1.

PART IV.

ANGLE BEAMS.

Angle beams are calculated as T beams, but in case of angle beams b is usually taken as $b = \frac{3}{8} C + \frac{a}{2}$, whilst for Tee beams $b = \frac{3}{4} C$ generally.

PART V.

RECTANGULAR BEAMS AND SLABS.

A slab is calculated by considering only a longitudinal section of an arbitrary width (generally of width equal to unity), this section does not differ from that of a rectangular beam.

In a "rectangular beam," that part of the concrete above the neutral axis is the only part compressed, and is alone considered in the calculations of resistance of a beam.

It is exactly what takes place in a Tee beam with the neutral axis inside the slab (apparent Tee beams as we call them, to distinguish them from the true Tee beams, *i.e.*, beams with the neutral axis outside the slab); all that has been said in connection with those beams applies equally well to rectangular beams and slabs; the symbol b. then refers to the width of the beam or that slice of slab under consideration. And when applied to the slab, h represents the height or efficient thickness e'.

In a slab, then, as $b = 1$ ft. for a mixture of 4 : 6 : 12,

$$e' = h = \sqrt{\frac{M}{108}}$$

and for a mixture of 3 : 6 : 12

$$e' = h = \sqrt{\frac{M}{76}}.$$

In the foregoing we have a rapid way of calculating ferro-concrete beams, and before concluding we shall have added a few examples met with in practice to illustrate the practical use of our tables.

We do not expect our readers to use the same constants as we do; they can prepare for themselves tables, using their own constants should they prefer our way of solving the different problems.

Our readers will also notice that we have not taken into consideration the "shear" on the beams, this was mentioned casually when discussing the thickness of the rib of a Tee beam.

Generally half the shear or a fraction of the shear is taken by the rib, and the remainder by the stirrups, except in very important work, such as a long span bridge where the stirrups are calculated to resist the whole shear.

Those interested in the calculation and distribution of stirrups in a beam to resist the shear can consult in the "Annales des Ponts et Chaussées" 3me semestre, 1906, Tome XXIII, a carefully-studied paper by Mr. Pendaries, Ingénieur des Ponts et Chaussées, Directeur des travaux de la Ville de Toulouse.

We have also omitted any reference to the adhesion of the concrete and steel. Neither shear nor adhesion were subjects we desired to discuss in this paper, so that readers will not find it strange if we barely mention these matters as being only complementary to the design of a beam.

TABLE III.—*For the Design of Beams requiring Steel in Compression.* (Figs. 14, 14*a* and 14*b*.)

In this table:
- $R = 15{,}624$ lb./in.², $m = 12$, h and u in inches.
- $R' = m r'$ in lb./in.², S_2 and S_1 in square inches.
- M_2 is always expressed in foot-pounds.
- $r = 700$ lb./in.², and $y = 0·35\,h$ for a mixture of 4 : 6 : 12.
- $r = 566$ lb./in.², and $y = 0·301\,h$ for a mixture of 3 : 6 : 12.

$\frac{h}{y} = i_1 = 2·86$ for a mixture of 4 : 6 : 12.

$\frac{h}{y} = i_1 = 3·325$ for a mixture of 3 : 6 : 12.

Values of $\frac{h}{u}$	Mixture 4 : 6 : 12. R' lb./in.²	Mixture 4 : 6 : 12. Compressive Reinforcement $S' = k' \cdot \frac{M}{h}$ in sq. ins. Values of k'.	Mixture 8 : 6 : 12. R' lb./in.²	Mixture 8 : 6 : 12. Compressive Reinforcement $S' = k' \cdot \frac{M}{h}$ in sq. ins. Values of k'.	Any Mixture. Additional Tensile Reinforcement $S_2 = k_2 \cdot \frac{M}{h}$ in sq. ins. Values of k_2.
6·0	4,396	0·003276	2,996	0·004807	0·0009217
6·5	4,705	0·003014	3,283	0·004321	0·0009077
7·0	4,968	0·002818	3,528	0·003908	0·0008961
7·5	5,198	0·002664	3,741	0·003701	0·0008862
8·0	5,397	0·002541	3,927	0·003492	0·0008778
8·5	5,575	0·002440	4,091	0·003332	0·0008705
9·0	5,730	0·002356	4,237	0·003186	0·0008641
9·5	5,870	0·002285	4,368	0·003071	0·0008584
10·0	5,998	0·002223	4,486	0·002972	0·0008534
10·5	6,114	0·002169	4,592	0·002888	0·0008478
11·0	6,216	0·002124	4,689	0·002815	0·0008449
11·5	6,310	0·002083	4,777	0·002751	0·0008412
12·0	6,398	0·002046	4,858	0·002695	0·0008379
12·5	6,478	0·002014	4,933	0·002644	0·0008348
13·0	6,552	0·001984	5,001	0·002599	0·0008321
13·5	6,620	0·001958	5,065	0·002559	0·0008295
14·0	6,684	0·001933	5,124	0·002522	0·0008271
14·5	6,743	0·001912	5,179	0·002489	0·0008249
15·0	6,798	0·001891	5,230	0·002458	0·0008229
16·0	6,898	0·001858	5,324	0·002410	0·0008193
17·0	6,986	0·001825	5,406	0·002359	0·0008161
18·0	7,064	0·001799	5,479	0·002319	0·0008132
19·0	7,137	0·001775	5,544	0·002285	0·0008106
20·0	7,199	0·001755	5,603	0·002255	0·0008085
21·0	7,257	0·001736	5,656	0·002228	0·0008065
22·0	7,308	0·001720	5,704	0·002204	0·0008046
23·0	7,355	0·001706	5,748	0·002182	0·0008030
24·0	7,399	0·001692	5,789	0·002163	0·0008014
25·0	7,439	0·001680	5,826	0·002146	0·0008001
26·0	7,476	0·001669	5,860	0·002130	0·0007988
27·0	7,510	0·001659	5,892	0·002115	0·0007976
28·0	7,542	0·001650	5,922	0·002101	0·0007965
30·0	7,599	0·001634	5,975	0·002078	0·0007945
40·0	7,799	0·001578	6,161	0·001998	0·0007877
50·0	7,920	0·001546	6,273	0·001952	0·0007837
60·0	8,000	0·001528	6,348	0·001923	0·0007811
∞	8,400	0·001429	6,720	0·001786	0·0007681

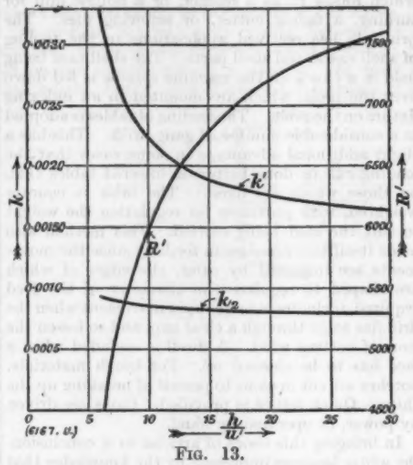
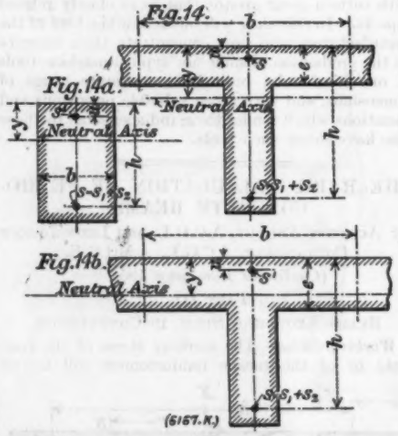


FIG. 13.

NOTE.—$k = \frac{8\,h}{M}$, so that $S' = k' \cdot \frac{M_2}{h}$, and $S_2 = k_2 \cdot \frac{M_2}{h}$.

Constants adopted in constructing the curves:—
- $R = 15{,}624$ lb. per sq. in.
- $r = 700$ lb. per sq. in.
- $m = 12$.

Units to be used in reading the curves:—
- h and u', in inches.
- R', in lb. per sq. in.
- M_2, in pounds × foot.
- S_2 and S', in sq. in.



PRACTICAL EXAMPLES ON FERRO-CONCRETE BEAMS TO ILLUSTRATE THE USE OF THE TABLES.

Examples of Rectangular Beams. I.

1. Rectangular beams at 2-ft. 6-in. centres are required to support a wooden flooring for a distributed load of 128 lb. per square foot inclusive of the weight of the flooring. Required, the depth of the beam and necessary reinforcement for a mixture of 4 : 6 : 12.

The beams are to be freely supported, span 20 ft.—

Load per foot run of beam $= w_1 = \frac{5}{2} \times 128 = 320$ lb.

Allowance for Beam $= w_2 = 150$ lb.

$\therefore$ Weight per foot run $= w = 470$ lb.

and Bending Moment $= M = \frac{w l^2}{8} = \frac{470 \times 400}{8}$

Let us take the width of beam $b = 9$ in. $= \frac{3}{4}$ ft. Now for a mixture of 4 : 6 : 12 from Table II:

$$h = \sqrt{\frac{M}{108\,b}} = \sqrt{\frac{23{,}500 \times 4}{3 \times 108}} = 17 \text{ in. say,}$$

and $y = \frac{h}{2·86} = 5·95$ in. and $r = 700$ lb./in.²

The necessary corresponding reinforcement is:

$$S = 0·0008694 \frac{M}{h} = \frac{0·0008694 \times 23{,}500}{17}$$

$$= 1·2 \text{ square inches.}$$

2. What would be the reinforcement if instead of taking that beam as previously designed, we were to increase its depth to 20·18 in., say?

In that case we would have:

$$\frac{M}{b\,h^2} = \frac{23{,}500 \times 4}{3 \times (20·18)^2} = 77·2$$

On looking at Table II we see that where:

$$\frac{M}{b\,h^2} = 77·2, \; \frac{h}{y} = 3·3, \text{ or } y = \frac{20·18}{3·3} = 6·1 \text{ in.}$$

and the concrete is working at $r = 566$ lb./in.², instead of 700 lb./in.².

The corresponding steel reinforcement is given by:

$$S = \frac{0·0008544 \times 23{,}500}{20·18} = 0·995 \text{ square inches.}$$

3. If, on the contrary, for some reason or other we had to reduce the depth of our beam to 16 in., say, what would then be our reinforcement?

In this case we will first have to find what bending moment a beam of 16 in. depth will take and for that depth what is the necessary reinforcement required?

We have, from Table II, for a mixture of 4 : 6 : 12, and stress on concrete $r = 700$ lb./in.²:

$$\frac{M_1}{b\,h^2} = 108 \quad \text{or} \quad M_1 = 108\,b\,h^2$$

$\therefore$ $M_1 = 108 \times \frac{3}{4} \times (16)^2 = 20{,}750$ ft./lb.

And for that beam:

$$S_1 = 0·0008694 \frac{M_1}{h} = \frac{0·0008694 \times 20{,}750}{16} = 1·125 \text{ sq. in.}$$

But we have to take a bending moment $M = 23{,}500$ ft.-lb.:

$\therefore$ $M_2 = (M - M_1) = 2{,}750$ ft./lb.

This moment M_2 will be taken by compressive reinforcements and additional tensile reinforcement to equalize same.

Suppose we place our compressive reinforcement at 2 in. (distance u) from the top edge of beam (Fig. 15):

$\therefore$ We have $\frac{h}{u} = \frac{16}{2} = 8$.

Looking at Table III, we have the distance $u = 2$ in.

HIGH-PRESSURE AND LOW-PRESSURE TURBINES O TH

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND O., LIMI

(For Descripti see Pag

Fig. 40.

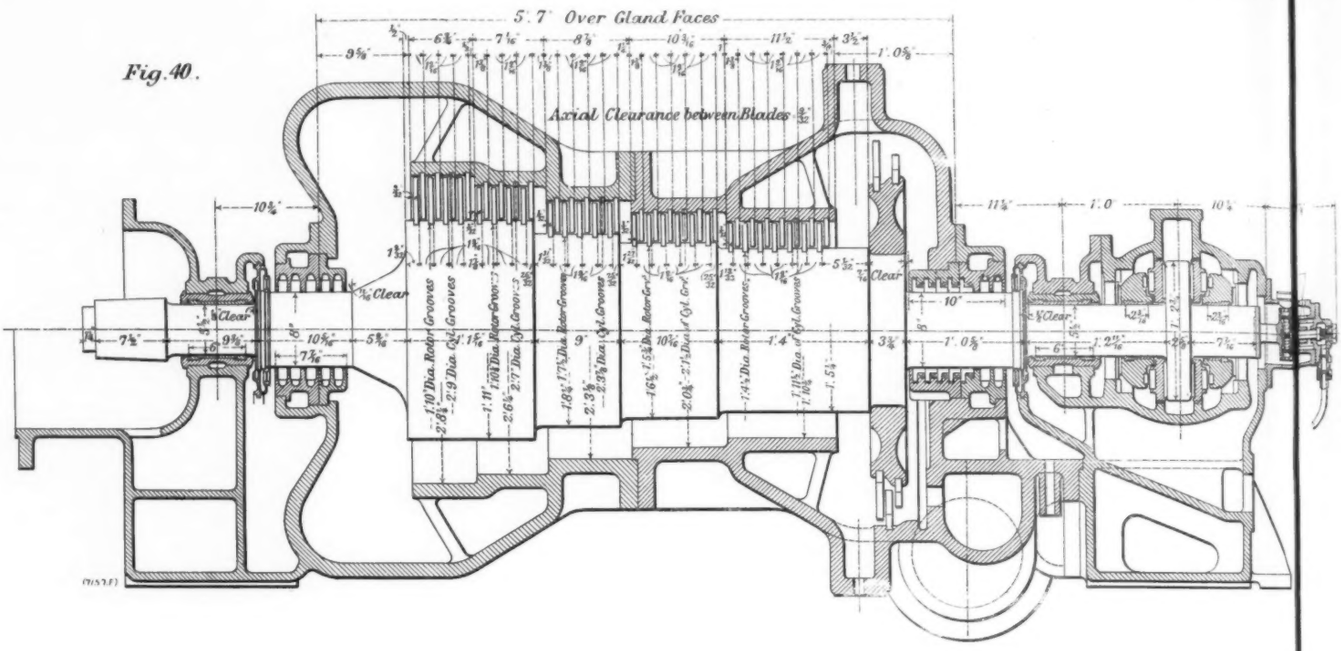


Fig. 45.

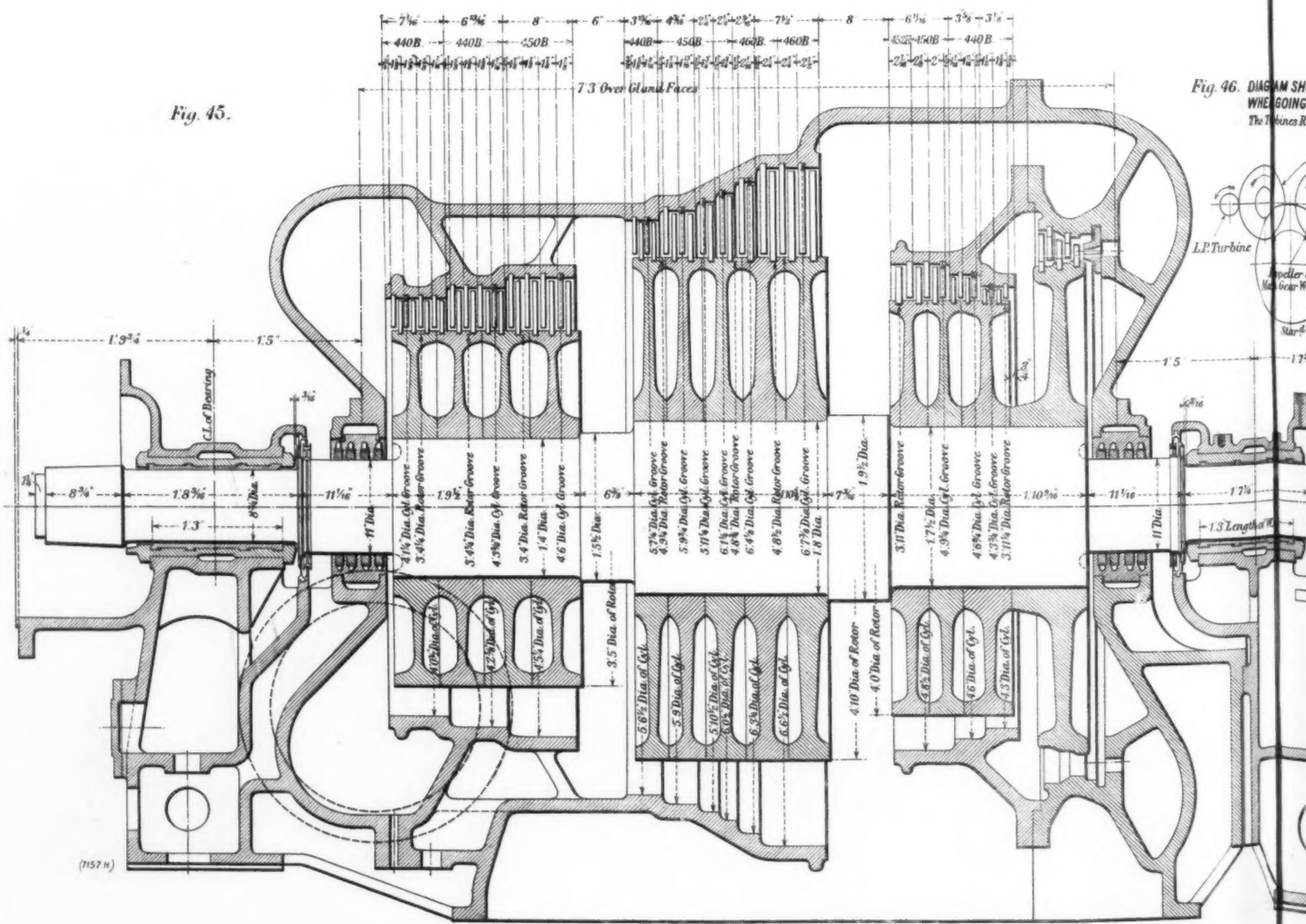


Fig. 46. DIAGRAM SHO
WHE GOING A
The Turbines Re

OF THE ITALIAN ATLANTIC LINER "CONTE ROSSO."

AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, DALMUIR.

(scription, see Page 223.)

Fig.41. PORT TURBINE LOOKING FORWARD TO OPPOSITE HAND FOR STARBOARD TURBINE.

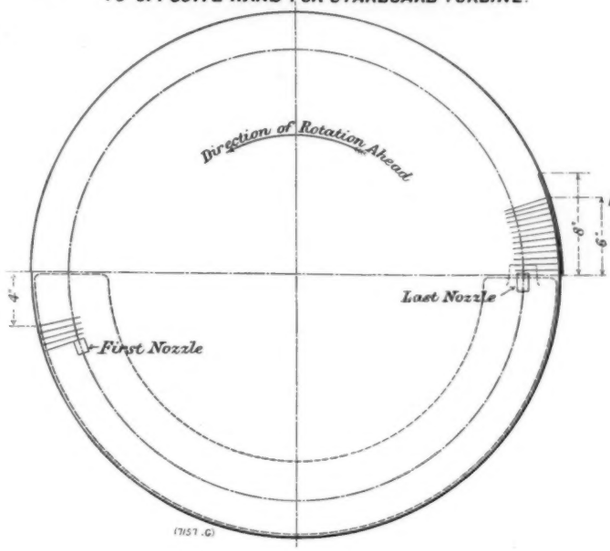
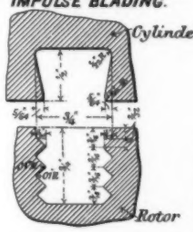


Fig.44. H.P. TURBINE GROOVES IMPULSE BLADING.



H.P. TURBINE GROOVES REACTION BLADING.

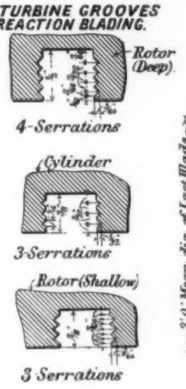


Fig.42.

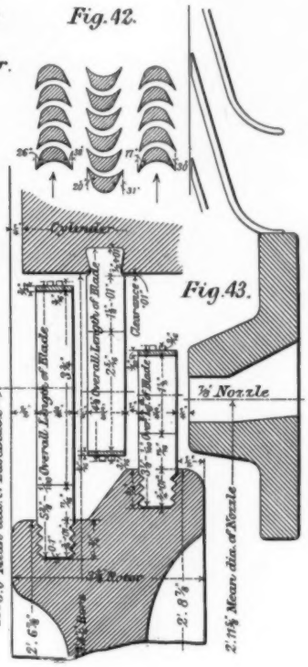


Fig.47. VIEW ON IMPULSE CYL.R BLADING WITH ROTOR REMOVED. LOOKING FORWARD ON PORT TURBINE.

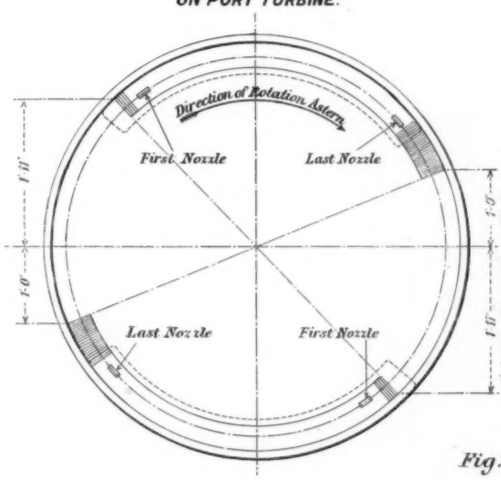


Fig.48.

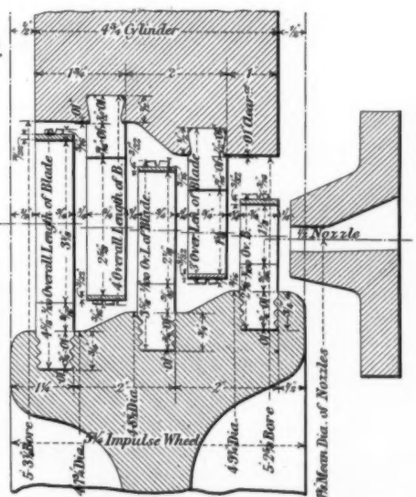


Fig.49.

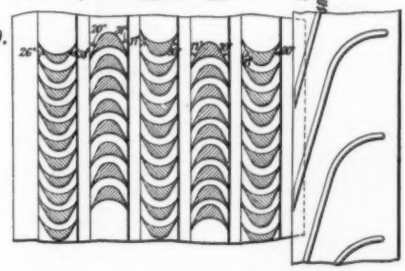


Fig.50. DETAILS OF REACTION GROOVES. CYLINDER GROOVES.

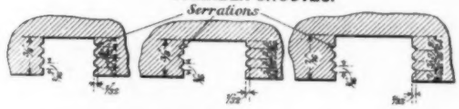


Fig.51. ROTOR GROOVES.

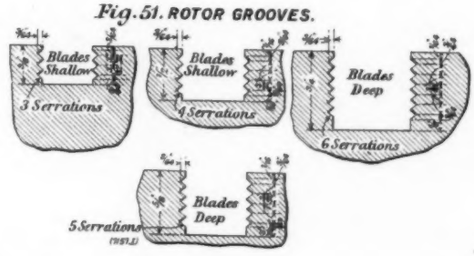


Fig.52. DETAILS OF IMPULSE GROOVE. CYLINDER. ROTOR.

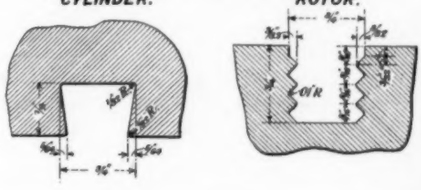
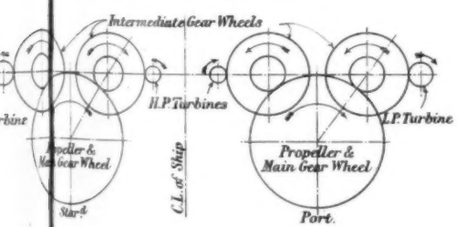
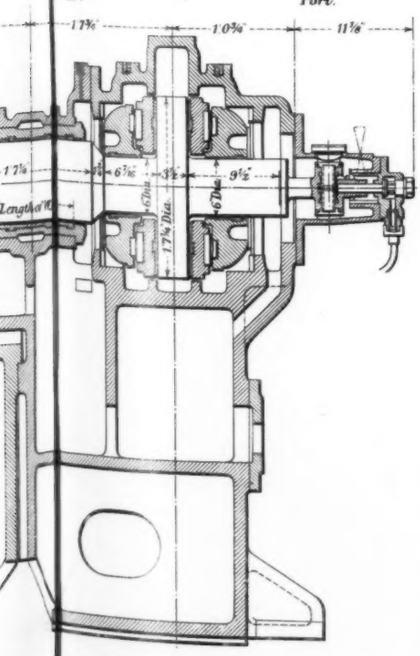


Fig.46. DIAGRAM SHOWING DIRECTION OF ROTATION WHEN GOING AHEAD. LOOKING AFT. The Turbines Revolve in same Direction as Propeller





so that $\frac{h}{u} = 8$. The steel will be working at a rate $R' = 5{,}397$ lb./in.².

Compressive reinforcement required is:

$$S' = k' \cdot \frac{M}{h} = \frac{0{\cdot}002541 \times 2{,}750}{16} = 0{\cdot}437 \text{ sq. in.}$$

And additional tensile reinforcement is:

$$S_2 = k_2 \cdot \frac{M}{h} = \frac{0{\cdot}0008778 = 2{,}750}{16} = 0{\cdot}15 \text{ sq. in.}$$

$\therefore$ Total tensile reinforcement $= S_1 + S_2 = 1{\cdot}275$ sq. in.
and compressive reinforcement $= S' \quad = 0{\cdot}437$ sq. in.

and $y = \frac{h}{2{\cdot}86} = \frac{16}{2{\cdot}86} = 5{\cdot}6$ in.

Example on Floor Design. II.

Required, to design a flooring of 20 ft. span with ribs $6\frac{3}{4}$ ft., centres to carry a super load of 112 lb. per square foot, using a mixture of 4 : 6 : 12.

1. *Design of Slab.*—

Span of slab = 6 ft. (Fig. 16.)

Considering 1 foot wide, we have per foot
run of slab weight of super load ... 112 lb.
Allowance for slab ... ... 58 lb.

Weight per foot run ... ... 170 lb.

For an *encastré* slab the bending moment:

$$M = \frac{w l^2}{10} = \frac{170 \times (6)^2}{10} = 612 \text{ ft./lb.}$$

From Table II, for a slab as $b = 1$ ft., and for mixture 4 : 6 : 12:

$$e' = h = \sqrt{\frac{M}{108}} = \sqrt{\frac{612}{108}} = 2\tfrac{3}{8} \text{ in.}$$

We will take:

$$e = 2\tfrac{3}{8} + \tfrac{5}{8} = 3 \text{ in., say}$$

and

$$S = 0{\cdot}0008694 \frac{M}{h} \times \frac{0{\cdot}0008694 \times 612}{2{\cdot}375} = 0{\cdot}224 \text{ sq. in.}$$

If we take rods of $\frac{3}{8}$ in. diameter, of area 0·112 sq. in., we can place them at intervals of $\frac{0{\cdot}112}{0{\cdot}224} \times 12$ in. $= 6$ in.

The distributing bars, *i.e.*, rounds placed at right angles to the reinforcement, will have a cross-section equal to $\frac{S}{2}$ *i.e.*, $\frac{0{\cdot}224}{2} = 0{\cdot}112$ sq. in.

If we chose $\frac{1}{4}$-in. rods of area = 0·0491 sq. in., we may place them at intervals of $\frac{0{\cdot}0491}{0{\cdot}112} \times 12 = 5\frac{1}{2}$ in., say:

Design of T-beams.—

$b = \frac{1}{4} \times 6\frac{3}{4} \, l \quad = 5$ ft., say
$e = 3$ in.

Load per ft. run on beam $= 6\frac{3}{4}$ (112 + 58 = 1,150 lb.
Allowance for beam ... ... = 150 lb.

Total per foot run $= w$ ... = 1,300 lb.

$\therefore$ Bending moment $= M = \frac{w l^2}{8} = \frac{1{,}300 \times (20)^2}{8}$

$= 65{,}000$ ft./lb.

Now from Table I, if:

$$\frac{M}{b e^2} = \frac{65{,}000}{5 \times (3)^2} = 1{,}445.$$

This corresponds to $\frac{h}{e} = 3{\cdot}75$, and as $e = 3$ in.

$\therefore h = 3{\cdot}75 \times 3 = 11\frac{1}{4}$ in.,

$\therefore y = \frac{h}{2{\cdot}86} = 3{\cdot}92$ in. and $r = 700$ lb./in.²

Corresponding tensile reinforcement from table is:

$$S = 0{\cdot}0008591 \frac{M}{h} = \frac{0{\cdot}0008591 \times 65{,}000 \times 4}{45}$$

$= 5$ sq. in., say.

2. How would the stress on the concrete be altered, also the position of the neutral fibre, and the tensile reinforcement affected if we increase the depth of the beam to 18 in., say?

In that case we have as data the following:

$M = 65{,}000$ ft./lb.; $h = 18$ in.; $e = 3$ in.; and $b = 5$ ft. 6 in.

We have, consequently, $\frac{h}{e} = 6$ but $\frac{M}{b e^2} = 1{,}445$ as before.

From Table I, the stress at which the concrete is working is given for

$$\frac{h}{e} = 6; \; r = \frac{M}{b e^2} \times 0{\cdot}1{,}978 + 114{\cdot}5$$

$= (1{,}445 \times 0{\cdot}1{,}978) + 114{\cdot}5 = 400$ lb./in.²

instead of the allowable working stress of 700 lb./in.².

$$y = \frac{m r}{R + m r} \cdot h = \frac{12 \times 400}{15{,}624 + (12 \times 400)} \times 18 = 4{\cdot}22 \text{ in.}$$

and tensile reinforcement is given by:

$$S = 0{\cdot}00083 \frac{M}{h} = \frac{0{\cdot}00083 \times 65{,}000}{18} = 3 \text{ sq. in.}$$

The position of the neutral axis has been slightly lowered and a reduction of 2 sq. in. obtained by increasing the depth of the girder to 18 in.

3. If, on the contrary, we had to reduce the depth of the girder to 9 in., how could the same properties of the beam as asked by question 2 be secured?

The position of the neutral axis would not be the same, being found (see Table II), by:

$$y = \frac{h}{2{\cdot}86} = \frac{9}{2{\cdot}86} = 3{\cdot}2 \text{ in.}$$

The working stress R would be 700 lb./in.².

Our data are now: $h = 9$; $e = 3$ in.; $b = 5$ ft.

$$\therefore \frac{h}{e} = \frac{9}{3} = 3$$

We must, therefore, first find what bending moment

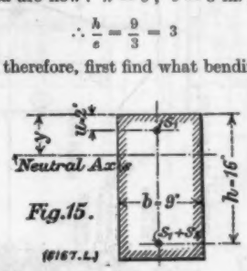


Fig. 15.

(6167.L.)

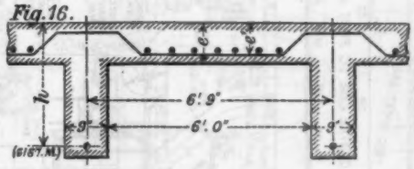


Fig. 16.

(6167.M.)

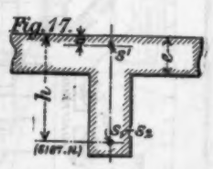


Fig. 17.

(6167.N.)

such a beam can take and what amount of tensile reinforcement is required.

From table I for

$$\frac{h}{e} = 3, \; \frac{M_1}{b e^2} = 971{\cdot}5$$

$$\therefore M_1 = 971{\cdot}5 \times 5 \times (3)^2 = 43{,}718 \text{ ft./lb.}$$

and

$$S_1 = 0{\cdot}000869 \frac{M_1}{h} = \frac{0{\cdot}000869 \times 43{,}718}{9} = 4{\cdot}21 \text{ sq. in.}$$

But we have to take a bending moment $M = 65{,}000$ ft./lb.

$$\therefore M_2 = 65{,}000 - 43{,}718 = 21{,}282 \text{ ft./lb.}$$

which must be taken by compressive reinforcement and additional tensile reinforcement.

If we place our compressive reinforcements at a distance $u = 1\frac{1}{2}$ in. (Figs. 16 and 17) from the top of beam, we have: $\frac{h}{u} = \frac{9}{1{\cdot}5} = 6$ and from Table III, when $\frac{h}{u} = 6$

$$R' = 4{,}396 \text{ lb./sq. in.}$$

and compressive reinforcements:

$$S' = 0{\cdot}003276 \frac{M}{h} = \frac{0{\cdot}003276 \times 21{,}282}{9} = 7{\cdot}75 \text{ sq. in.}$$

and additional tensile reinforcement:

$$= S_2 = 0{\cdot}0009217 \frac{M_2}{h} = \frac{0{\cdot}0009217 \times 21{,}282}{9}$$

$= 2{\cdot}18$ sq. in.

$\therefore$ Total tensile reinforcement $= S_1 + S_2 = 6{\cdot}39$ sq. in.
Compressive reinforcement $= S' \quad = 7{\cdot}75$ sq. in.

These examples show us that no economy, whatever, can be derived by using beams with compressive reinforcements, and instead of reducing the depth of the beam it would be more advisable to change the distance from centre to centre of beams. These tables are so easy to handle that the designer can in a short time alter his design and ascertain which is the most economical design for a particular case.

(To be continued.)

THE ITALIAN ATLANTIC LINER "CONTE ROSSO."

(Concluded from page 199.)

WE now propose to complete our description of this vessel by giving some particulars of the propelling and auxiliary machinery, which we illustrate on pages 224, 225, 227 and 232, and on Plate XIII published with this issue. The general arrangement of the machinery in the ship is shown by the elevation and plan reproduced in Figs. 32 and 33, on page 224, and by the transverse sections, Figs. 34 to 39, on page 225. The propelling machinery, which was designed and constructed by the builders of the vessel, consists of two sets of compound steam turbines of the Parsons impulse and reaction type, each driving a separate propeller shaft through double-reduction, double-helical gearing. A photograph of the starboard set of turbines and gearing in course of erection at Messrs. Beardmore's works is reproduced in Fig. 59, on page 232, and their design and construction can be followed by examining the line engravings on Plate XIII and on page 227.

Each set comprises a high-pressure and a low-pressure turbine, sections and details of which are given in Figs. 40 to 52, on Plate XIII, and the turbine shafts carry pinions gearing with the wheels on a pair of intermediate shafts. The four pinions on these two shafts gear with two wheels on the propeller shaft, as will be clear from Fig. 46, on Plate XIII. Drawings of the gearing are reproduced in Figs. 54 to 58, on page 227, and Fig. 53, on page 226, shows a gear casing suspended from an overhead crane. Both pinions and wheels were cut in the Dalmuir shops, the former being of 3 per cent. nickel steel made at Parkhead. The gear boxes, as will be gathered from Figs. 56 to 58, are of particularly massive design, and the material employed in them has been carefully distributed in order to prevent distortion which has been the cause of trouble in some geared-turbine ships. Each set in the Conte Rosso transmits about 11,000 s.h.p. with a propeller speed of 92 r.p.m.

The turbines are designed to work with steam at 180 lb. per square inch pressure and 200 deg. F. of superheat at the turbine stop valves. The parts of the turbines in contact with superheated steam are of cast steel, and the blades are of special phosphor-bronze. The designed speed of the high-pressure turbines is 2,950 r.p.m., and of the low-pressure turbines 1,686 r.p.m.; these speeds were, however, exceeded by 20 per cent. on trials under steam in the shops. Astern elements, to give ample manœuvring power, are incorporated in each low-pressure turbine casing at the forward end, as shown in Fig. 45, on Plate XIII. Cockburn-Aspinall governors are fitted to prevent increase of speed due to the racing of the propeller, and the apparatus is also arranged to shut off the supply of steam in the event of failure of the forced lubrication system or of the reduction of the oil supply pressure below a pre-determined limit.

With regard to the general arrangement of the machinery, to understand which reference should be made to Figs. 32 to 37, on the two following pages, it should be mentioned that ample space has been left round all the units to give easy access for inspection and overhaul. The engine-room has an upper and a lower platform, shown in Fig. 32, the former constituting the starting platform and giving access to the main ahead and astern stop valves, and also to the turbines and gearing. From the lower platform all the pumps, such as the feed, air, ballast pumps, &c., are regulated and attended to. This arrangement gives a clear starting platform from which a view of the whole engine-room is obtained. The lead of the steam pipes for the ahead and astern turbines is such that there are no main pipes above the turbines or gear cases, and consequently the upper parts of the turbine casing, the rotors, gear-case covers and wheels can all be removed for examination without disturbing any important pipe joints. Furthermore, the absence of steam pipes over the machinery gives a particularly airy appearance to the engine room, and also improves the atmosphere. The ventilation of the engine-room is on a special exhaust system, and during the trials it was found that the exhaust fans were able to keep the engine-room at a comfortable temperature at all times without employing the inlet fans. This installation, which has been carried out by the Thermotank Company, of Glasgow, provides for a renewal of the air in the different compartments up to 60 times per hour according to requirements. The various accom-

GENERAL ARRANGEMENT OF MACHINERY AND BOILERS OF THE T.-S.S. "CONTE ROSSO."

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, DALMUIR.

Fig. 32.

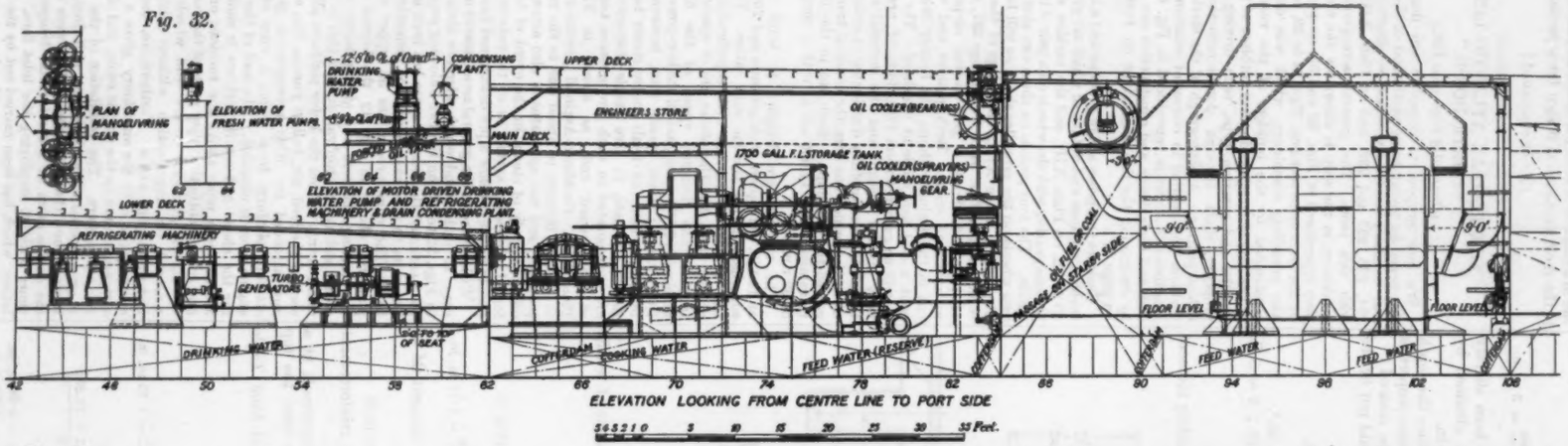
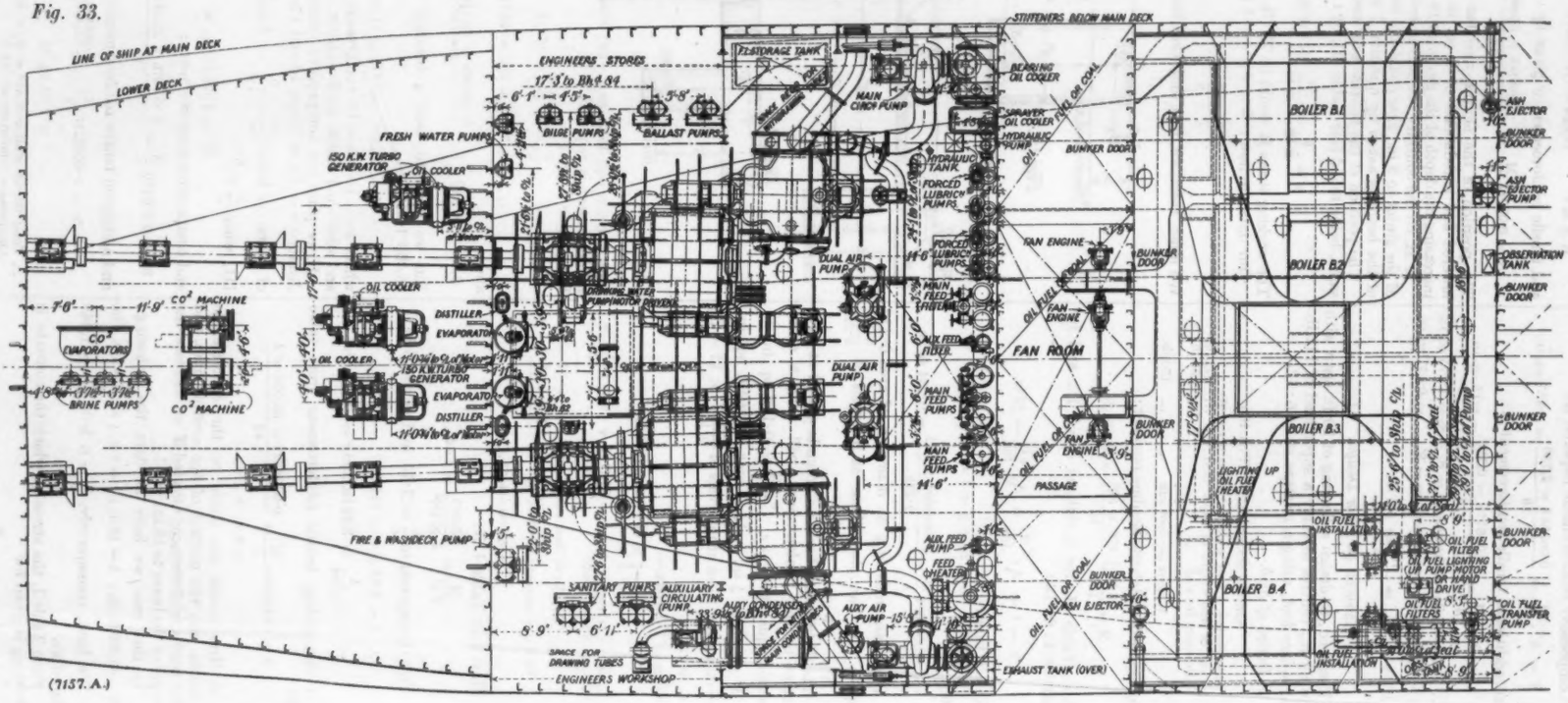


Fig. 33.



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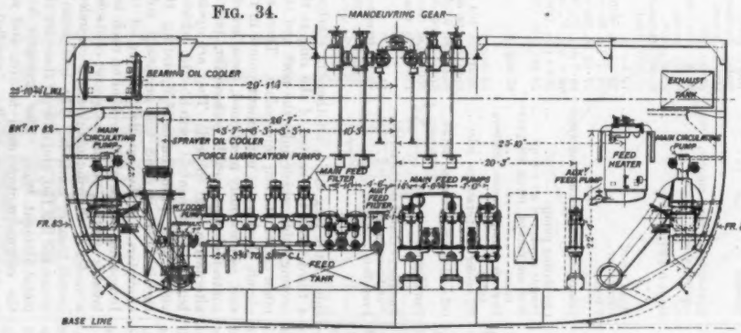
GENERAL ARRANGEMENT OF MACHINERY AND BOILERS OF THE T.-S.S. "CONTE ROSSO."

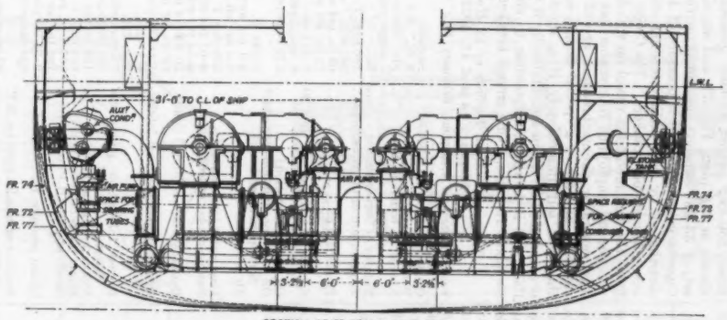
CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, DALMUIR.

FIG. 34.



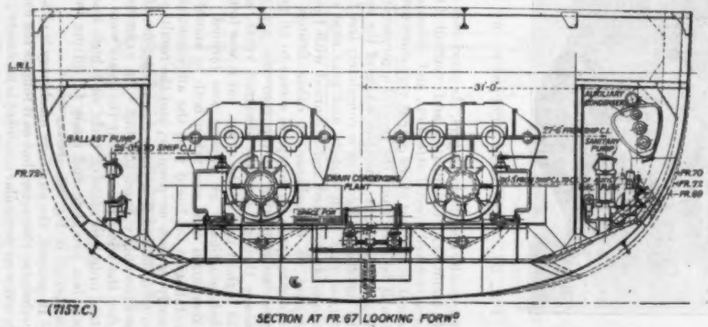
SECTION AT FR. 79 LOOKING FORWD

FIG. 35.



SECTION AT FR. 79 LOOKING AFT

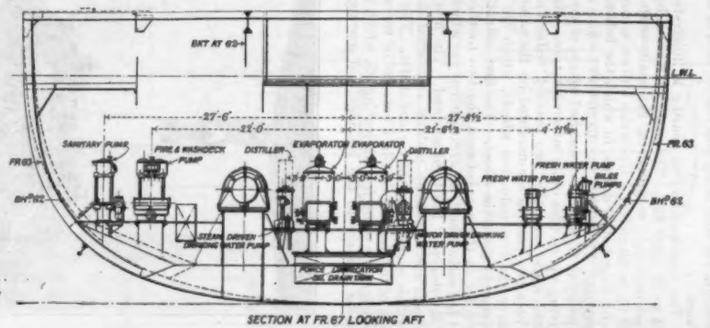
FIG. 36.



(7157.C.)

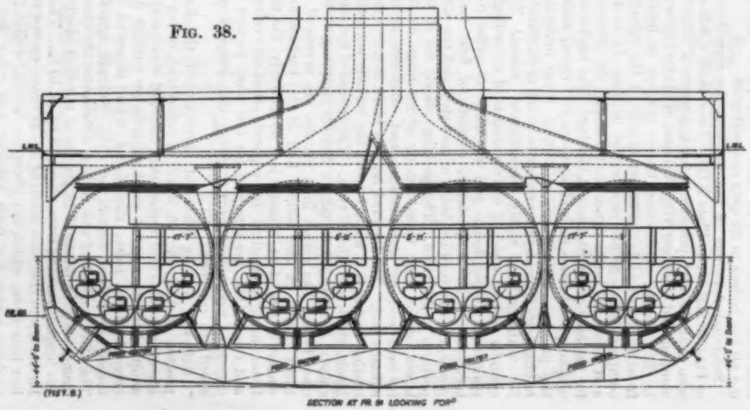
SECTION AT FR. 67 LOOKING FORWD

FIG. 37.



SECTION AT FR. 67 LOOKING AFT

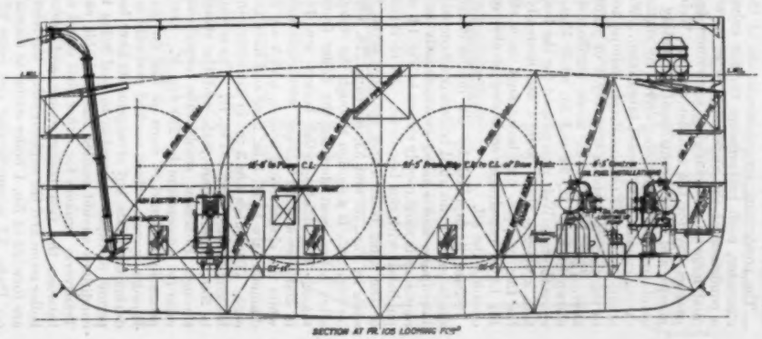
FIG. 38.



(7157.S.)

SECTION AT FR. 94 LOOKING FORD

FIG. 39.



SECTION AT FR. 105 LOOKING FORD

accommodations in the ship are thoroughly warmed and ventilated by Thermotanks, so arranged that the air in every compartment is exchanged at the rate of from 8 to 12 times per hour, and the capacity of the installation is sufficient to maintain a comfortable temperature under the coldest weather conditions.

The condensing arrangements are of the standard character, each low-pressure turbine exhausting into a condenser of the underslung type, as is now usual in all large sets, since it gives a minimum length for the passage-way for the exhaust steam. Weir's dual air pumps and Paul's centrifugal circulating pumps are employed, the latter being driven by enclosed reciprocating engines with forced lubrication. We may here mention that no turbine-driven pumps are employed in the ship since steam economy is of primary importance. The location of these auxiliaries is clearly shown in Figs. 32, 33 and 35, while Figs. 33 and 34 show the four Weir pumps used for the forced-lubrication system; three pumps are normally employed for this purpose, one being kept as a stand-by. A De Laval centrifugal separator is also installed for cleaning the oil.

Steam is supplied by six double-ended and two single-ended cylindrical boilers constructed by Messrs. Beardmore and located symmetrically in two boiler rooms, as is most clearly shown in Fig. 14, on Plate XI, published with our last issue. An elevation and plan of the after boiler room are also given to a larger scale in Figs. 32 and 33, on page 224, while Fig. 38, on page 225, is a section through the stokehold of the after boiler-room showing the boiler fronts and uptakes. The double-ended boilers are 16 ft. 3 in. in diameter and 22 ft. long, with eight furnaces each, while the single-ended boilers, which are of the same diameter, are 11 ft. 3 in. long and have four furnaces each. The tubes are 3 in. in diameter, and the total heating surface is 42,154 sq. ft. The working pressure is 200 lb. per square inch, and the steam is passed through Robinson smoke-tube superheaters, which raise its temperature by 220 deg. F. The boilers are primarily designed to burn oil fuel on the Wallsend-Howden system, which worked perfectly satisfactorily during the trials, but arrangements have been made to permit of rapid conversion to coal firing if economic conditions should render this desirable at any time. Transverse bunkers for either coal or oil are situated between the two boiler rooms and between No. 2 boiler room and the engine-room; the reserve bunkers are forward of No. 1 boiler-room, as shown in Fig. 14, on Plate XI accompanying our issue of 17th inst. The oil fuel installation consists of duplicate units in each boiler-room, either of which is capable of supplying all the boilers in its own compartment.

Sectional drawings of the turbines are reproduced in Figs. 40 and 45, on Plate XIII. From these it will be seen that the high-pressure rotor comprises a velocity compounded wheel carrying two rows of blades followed by five groups of reaction blades ranging in height from 2⅞ in. to 4½ in. Further details of the velocity compounded stage are represented in Figs. 41 to 44, and below the latter figure is also shown the grooving for the high-pressure reaction blading. The blades are of phosphor-bronze in both cylinder and rotor, whilst the packing sections are of copper, these materials having been found by experience to be the most suitable for withstanding highly superheated steam. The cylinder casing, which it will be seen is of exceedingly plain and simple design and not liable to suffer distortion at high temperature, consists of four main pieces, the two forward being of cast steel and the after portions of cast-iron. The packing glands are of the latest carbon ring type, having seven rings at the forward end or high-pressure end, and five at the exhaust end. The forward bearing block is a separate casting in which is incorporated the turbine adjusting block, which is of Michell type. The aft end of the rotor spindle is arranged to take a flexible coupling of the claw type. The steam inlet nozzles are arranged in three groups on the bottom half of the turbine and consist of sets of 24, 3 and 5 jets respectively, the two latter being controlled by separate shut-off valves, and these latter are intended for use when powers in excess of that necessary for giving the designed sea speed are required.

Referring to the sectional elevation of the low-pressure turbine, Fig. 45, it will be noted that, owing to the considerable size of the rotor, the solid construction adopted in the case of the high-pressure turbine has been departed from, the blades being mounted on forged steel discs shrunk on to a common spindle. The after portion of this turbine constitutes the ahead element and consists of 11 groups of reaction blading, the heights varying from about 3½ in. to 10 in. These blades are in this case made of 70–30 brass, except the last four rows, which are phosphor-bronze, whilst the packing pieces for both cylinder and rotor are of 70–30 alloy. This material has been found to be quite suitable, where the steam is no longer superheated. Details of the grooving are given in Figs. 50 and 51. The astern element incorporated in this casing consists of six expansions, the first being a velocity-compounded wheel with three rows of blades. The blading for this stage is followed by groups of reaction blading. The astern casing is of cast steel, whilst the remainder of the turbine cylinder is cast-iron. Similar adjusting blocks and flexible couplings to those adopted for the high-pressure turbine are also fitted in this case. The glands for this turbine, being subject only to low pressure are both alike, and consist each of four carbon rings.

The double-reduction gearing is illustrated in Figs. 54 to 58, page 227. The main gear wheel has a heavy cast-iron hub, mounted on the main shaft (which is 23 in. in diameter). Upon this hub are secured the two solid forged steel drums, in which the helical teeth are formed. This wheel, the diameter of which is approximately 10 ft. 6 in. has a finished weight of some 40 tons, giving a good idea of its massive nature. Meshing into this wheel are the two second reduction pinions. These two pinions are mounted on the same shafts as carry the first reduction wheels, which are of similar design to the main wheel. The first reduction wheels revolve in the gap between the two toothed portions of the main wheel, an arrangement for which the term "interleaved" has been adopted. The first reduction wheels are driven by pinions connected through the flexible couplings to the turbine shafts. The lower portion of the massive cast-iron case below the supporting feet forms a sump for lubricating oil, which is supplied under pressure to the bearings and gearing by means

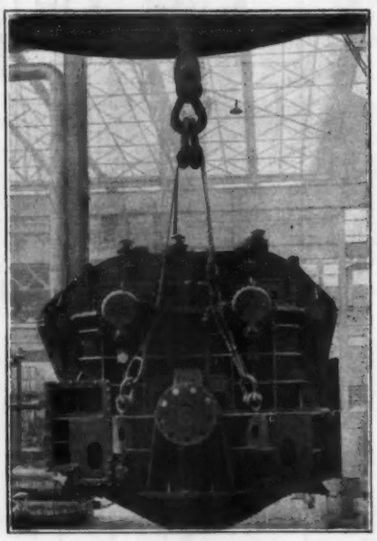


Fig. 53. Gear Case Suspended by Crane.

of specially designed sprayers. As previously mentioned the facilities for examination and overhaul of these gears have received special attention, and access can be obtained to any part of the gear at very short notice, whilst it will be seen from the general arrangement drawing (Fig. 32, page 224) that the whole of the space above the turbines and gearing is completely free from pipes, &c., so that both turbine and gear case covers and rotors can be lifted and examined with the minimum amount of disturbance of other fittings and with adequate space for complete access to all parts. Any gases accumulating in the gear-case are allowed to escape through specially designed vents, situated on the highest part of the cover, but it was found on trial that practically no vapour was formed. The most exceptional care was taken both in manufacture and installation on board that the alignment should be as nearly perfect as possible, and the results experienced on trial showed that this extreme care manifested itself in exceedingly quiet running. An examination made after the trials proved that the gears were all in first-class order, in spite of their very high loading. The gear-box complete and ready for lifting into place is illustrated in Fig. 53, above.

In general, the auxiliary machinery is of a very comprehensive character, but as it follows the usual modern practice no particular comment is necessary; the various units are all shown in Figs. 32 to 39, on pages 224 and 225. The equipment of measuring and recording apparatus is particularly complete and includes pneumercators for the oil bunkers, distance reading thermometers, recording gauges, torsionmeters, tachometers, &c., to give information as to the conditions prevailing at any time. It should also be mentioned that full provision is made for withdrawing the tail-shaft, when required, and for shipping the spare shaft carried. The special gear provided in the tunnel for this operation is of the most complete character. The navigational instruments fitted are also of the most modern type and include a Sperry gyroscopic compass.

A few particulars of the electric light and power installation may also be given, since this includes somewhat unusual features. The plant consists of three 150-kw. geared turbine generators located as shown in the plan, Fig. 33, and an oil-engine driven set, of 35 kw. capacity, mounted on the shelter deck. Current is generated at a pressure of 110 volts and is distributed by ring mains feeding remote-controlled automatic circuit breakers. The Conte Rosso is, we believe, the first merchant vessel on which the Admiralty practice of employing ring mains has been followed. The generator circuit breakers are of 1,500 amperes capacity, and are of a special design, so arranged that they cut out immediately if a short-circuit should occur, but close again automatically if the short clears itself; it is however, impossible to close them while the short remains. One circuit breaker feeds the port

Table I.—*Mean Records of 12 Hour Trials, February 14 and 15, 1922.*

Trial commenced 4.35 p.m., February 14.; finished 4.35 a.m. February 15.	
Condition of sea	Smooth.
Wind	S.W. 2–3 Beaufort.
Number of boilers in use	Six double-ended and one single-ended.
Number of burners in use	52.
Temperature of oil at burners	186 deg. F., forward. 248 deg. F., aft.
Pressure of oil	60 lb. per sq. in., forward. 71 lb. per sq. in., aft.
Specific gravity of oil fuel at 60 deg. F.	0·913 aft. 0·895, forward.
Oil fuel consumption	178 tons per 24 hours.
Oil fuel consumption per shaft horse-power per hour	0·934 lb.
Air pressure	3·1 in., forward. 3·4 in., aft.
Feed water temperature	210 deg. F.
Double strokes of feed pump	9·07 per min., port. 9·54 per min., centre.
Double strokes of oil fuel pump	10·83 per min., forward. 12·55 per min., aft.
Double strokes of forced lubrication pump	P.O., 20 per min. P.I., 22½. S.I., 22½.
Forced lubrication pump discharge	71, sprayers. 28, bearings.
Steam pressure at boilers	198 lb. per sq. in.
Steam temperature at boilers	644 deg. F.
Steam pressure H.P. receiver	167·5 lb. per sq. in., port. 162 lb. per sq. in., starboard.
Steam pressure L.P. receiver	9·35 lb. per sq. in., port. Gauge incorrect, starboard.
Number of nozzles open on H.P. turbine	27, port and starboard.
Torsion	100·3, port. 100·4, starboard. 100·35, mean.
Revolutions per minute, propeller shaft	85·99, port. 85·43, starboard. 85·71, mean.
Shaft horse-power	8,940, port. 8,880, starboard. 17,820, total.
Mean speed	19 knots.
Barometer	29·85 In. Mercury.
Vacuum	28·7 In. Mercury, port. 27·95 In. Mercury, starboard
Temperature of circulating water	46·5 deg. F., inlet. 69·0 deg. F., outlet.
Circulating pumps	208 r.p.m. (mean).
Double strokes of air pumps	28 per min. (mean).
Wet air pumps, mean temperatures	63 deg. F.
Dry air pump, mean temperatures	54 deg. F.
Oil cooler temperatures, inlet	Bearings, 104 deg. F. Sprayers, 96 deg. F.
Oil cooler temperatures, outlet	Bearings, 93 deg. F. Sprayers, 88 deg. F.
Fan engines	360 r.p.m. (mean), forward. 430 r.p.m. (mean), aft.
Auxiliary exhaust (led to turbines and feed heater)	11·5.
Propellers	20 ft. diameter; 24 ft. 9 in. pitch; 130 sq. ft. developed area.

side of the ring main, another the starboard side and a third feeds the centre of the ring at the cross-connecting cable which links the port and starboard ring main cables at their mid-points. There are 16 branch circuit breakers at convenient points in the ring main and, as previously mentioned, these are of the remote-controlled type; each is, however, provided with an alternative local control. They are operated by push buttons on a control switchboard, which is also provided with push buttons operating the generator circuit breakers, and the necessary voltmeters and ammeters for the parallel running of the machines. Indicating lamps are provided on each branch circuit-breaker control, on the generator controls and also on a model of the ring main which encircles the branch circuit-breaker controls. The total number of lamps connected is 3,150, and most of these are of the 30-watt, metal-filament type. The aggregate horse-power of the various motors used is 510, and all the larger machines are automatically controlled. A complete fire-alarm system is installed, as well as loud-speaking telephones, intercommunication telephones on the Relay Automatic System, voice pipes and electric bells.

As mentioned in our previous article, on page 198 *ante*, the speed trials, which were carried out on the

DOUBLE-REDUCTION GEARING OF THE T.-S.S. "CONTE ROSSO."

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, DALMUIR.

Fig. 54. SECTION THRO' C.C. LOOKING OUTBOARD

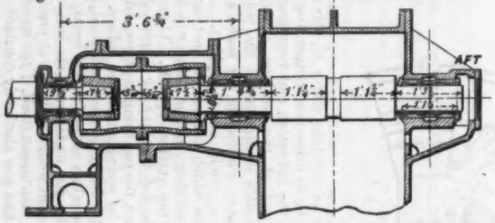


Fig. 56.

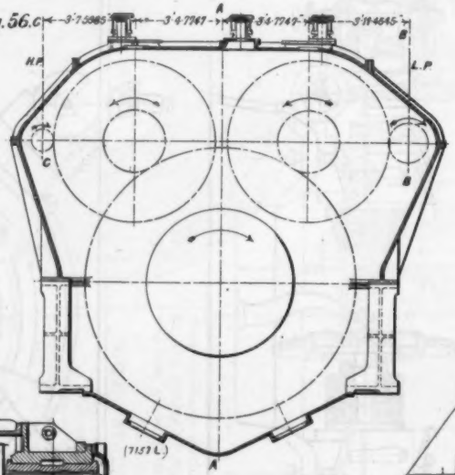


Fig. 55. SECTION THRO "BB" LOOKING INBOARD

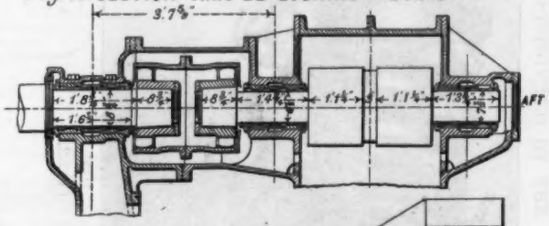


Fig. 57. SECTION THROUGH A.A.

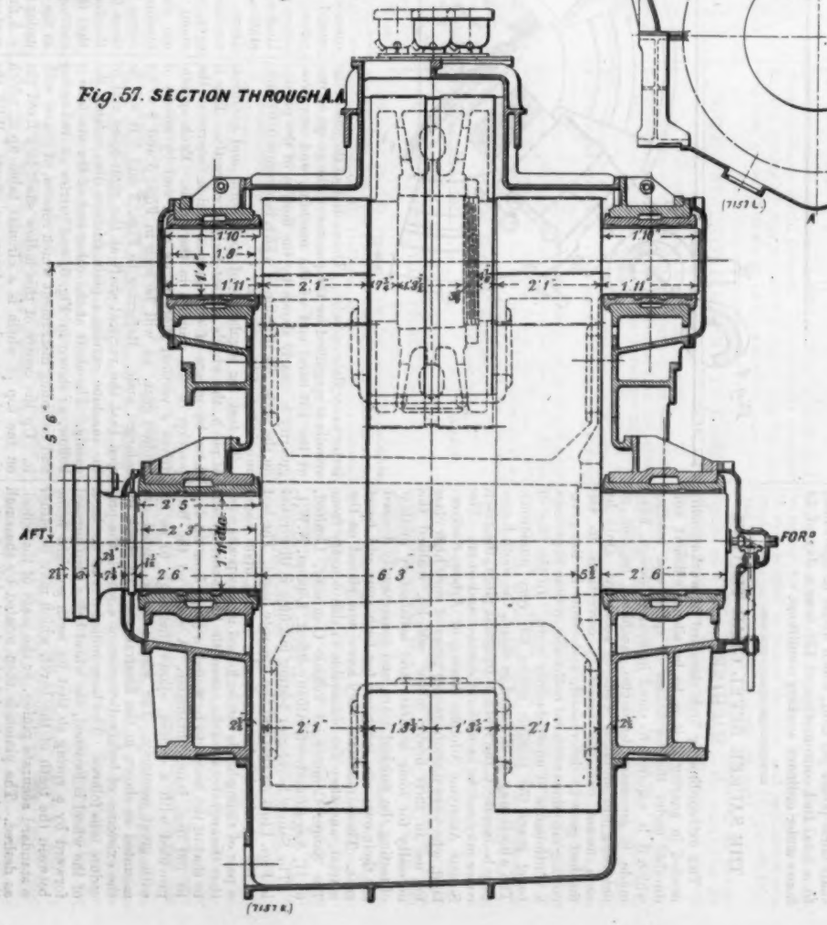
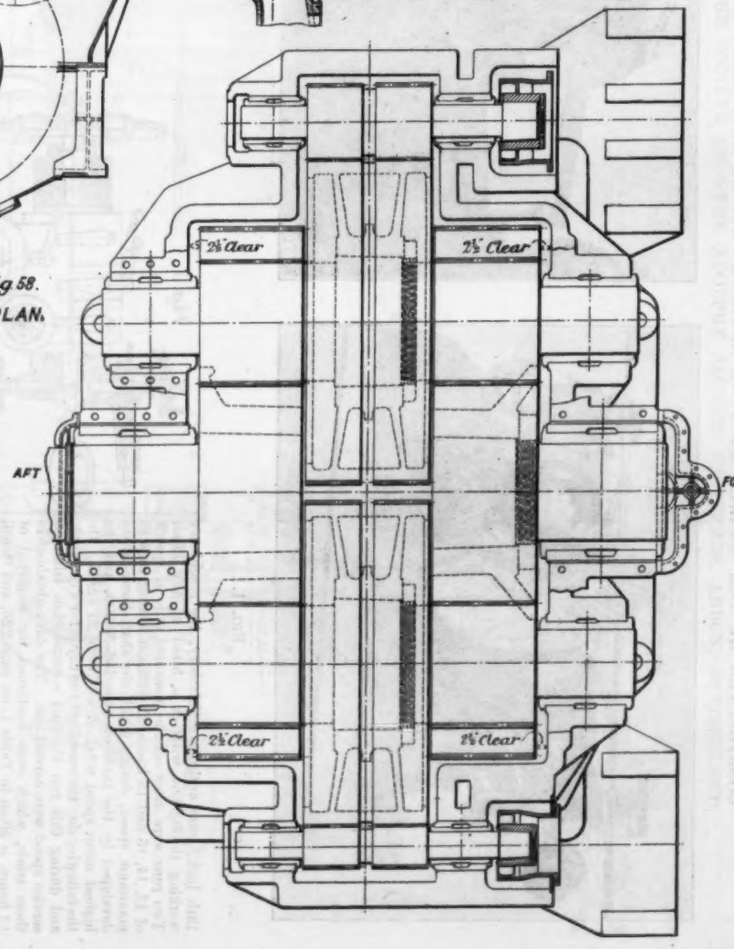


Fig. 58. PLAN.



BEVEL GEAR TESTING MACHINE.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME ADOLPHE SAURER, ENGINEERS, ARBON, SWITZERLAND.

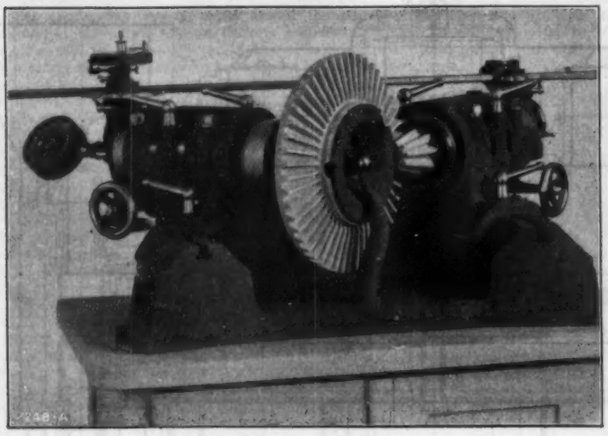


FIG. 1.

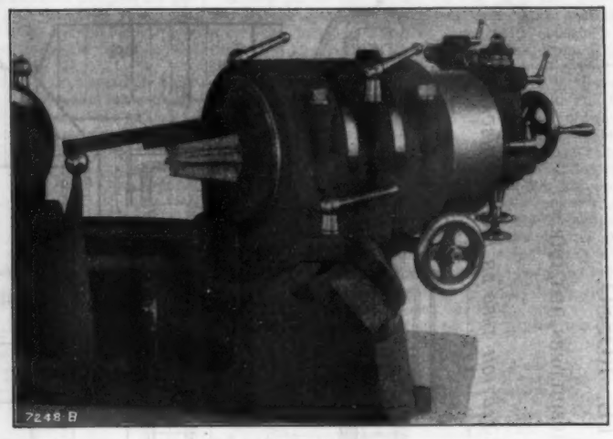


FIG. 2.

13th inst., were entirely satisfactory, the machinery working throughout without a hitch of any kind. Two runs were made on the measured mile at speeds of 12, 14, 16 and 18 knots, in addition to four runs at maximum speed, during which the shaft horse-power developed by the turbines exceeded 20,000, and the highest mean speed attained was over 20 knots. On the following day the vessel left the Clyde for Plymouth, and during this run the fuel consumption trials at service speed were carried out. The data obtained in these trials, which were continued for a period of 12 hours, is given in Table I. on page 226, and it will be seen that the mean shaft horse-power developed was 17,820, giving the vessel a mean speed of 19 knots. The consumption of fuel oil works out at 0·934 lb. per shaft horse-power per hour, which would be equivalent to a total fuel consumption of 178 tons a day of 24 hours under ordinary working conditions.

THE SAURER BEVEL GEAR TESTING MACHINE.

THE extraordinarily high standard of workmanship needed in gearing if it is to be silent, efficient and durable under the conditions of speed and loading which it is required to stand in modern design, have made it necessary to devise machines capable of detecting the minutest want of accuracy. Only by such means can the necessary corrections to the finished gear be determined, and errors in the gear-cutting machines rendered noticeable in time to prevent a continuance of unsatisfactory work. In the case of bevel gears the possible errors are very numerous. The wheels may be distorted in shape, the tooth forms may be incorrect, the teeth of irregular pitch, the pitch cones may not be in uniform contact and so on. The Société Anonyme Adolphe Saurer, of Arbon, Switzerland, who were manufacturing gears of very high class for use in their heavy motor vehicles, realised the necessity for some accurate and satisfactory method of testing the finished gears, and consequently devised for their own use, machines for both spur and bevel gear. These machines they have now placed on the market, and they are obtainable in this country from The Saurer Commercial Vehicle Company, Limited, of 21, Augustus-street, Albany-street, London, N.W.1.

The Saurer bevel-gear testing machine is illustrated in Figs. 1 to 6, on this and the opposite pages. The bed of the machine is a heavy, circular casting, upon which a pair of sliding heads can be locked in any position, so that the angle between the axes of the heads corresponds to that of the bevels to be tested, a range from 52 deg. to 150 deg. being obtainable. A scale on the bed, provided with a vernier, allows this angle to be set with great accuracy. The wheels to be tested are mounted as shown in the illustrations. To check for the existence of bodily distortion of a wheel, the procedure is as follows. The large milled nut at the back of the wheel is loosened, the wheel being then pressed forward by a spring so that its teeth go right home between the teeth of the bevel, which may be either a standard accurate pinion, or the mate of the wheel, as desired. The pinion is then rotated by the small hand wheel shown at the right hand end of Fig. 3. Any distortion of the wheel will cause the spindle of the latter to oscillate endwise. The motion of the end of the spindle is magnified by the pointer of the gauge shown at the left-hand end of the machine, and any irregularity is clearly shown by the motion of the pointer on the scale, one division of which represents 0·01 mm. movement of the spindle.

Fig. 3.

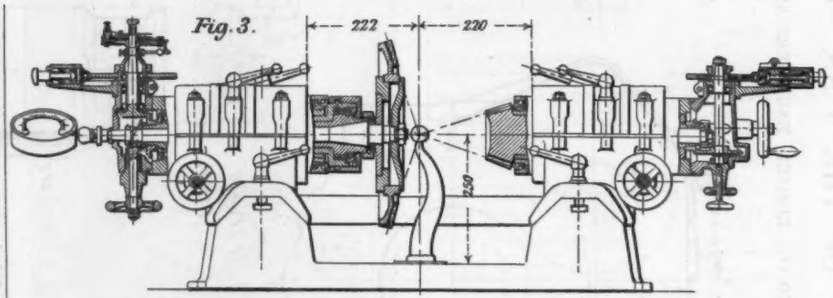
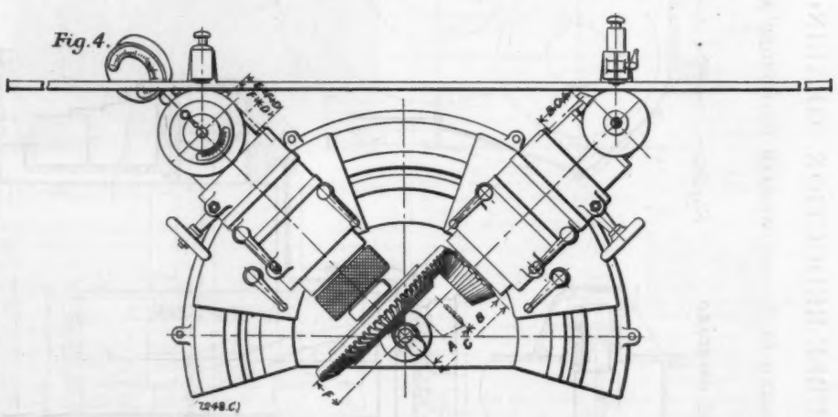


Fig. 4.



To test for regularity of tooth-form and evenness of pitch, the wheels are set to gear correctly. This is done by means of end gauges, which determine the position of the spindles in the heads. Each spindle drives a vertical shaft at its outer end by means of friction gear, as will be seen in Figs. 5 and 8 to an enlarged scale. Referring to Figs. 3 and 5 it will be seen that the vertical shaft at the right-hand end of the machine carries a plain friction disc outside the casing. The shaft at the other end of the machine is hollow, as shown in Fig. 5, and carries an indicating and recording instrument which rotates, of course with it. Up the centre of this hollow shaft is a fixed pin on the top of which is a circular table upon which the graphic records are drawn on charts. With the arrangement, so far as we have described it, the consequence of rotating either of the main gear spindles would be to drive one friction disc idly round, and to rotate the indicating and recording instrument at the other end of the machine round the fixed chart. Under such circumstances the pointer would remain stationary relative to its scale, and the pen would draw a circle on the chart. At the end of the machine which carries the instrument, there is, however, another friction disc which can be rotated about the vertical spindle. These two friction discs are coupled together by a rod at the back of the machine, the rod being kept pressed hard against their edges by spring controlled rollers. The diameters of these friction discs are so adjusted, in conjunction with the diameters of the friction bevels already mentioned, that the disc underneath the indicating and recording instrument would be driven at precisely the same speed as the instrument itself, if the speed ratio of the bevels under test was absolutely constant.

A finger rotating with the latter disc is brought into contact with a stop on the instrument, and is so adjusted that the pointer is moved to the centre of its scale,

BEVEL GEAR TESTING MACHINE.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME ADOLPHE SAURER: ENGINEERS, ARBON, SWITZERLAND.

Fig. 5.

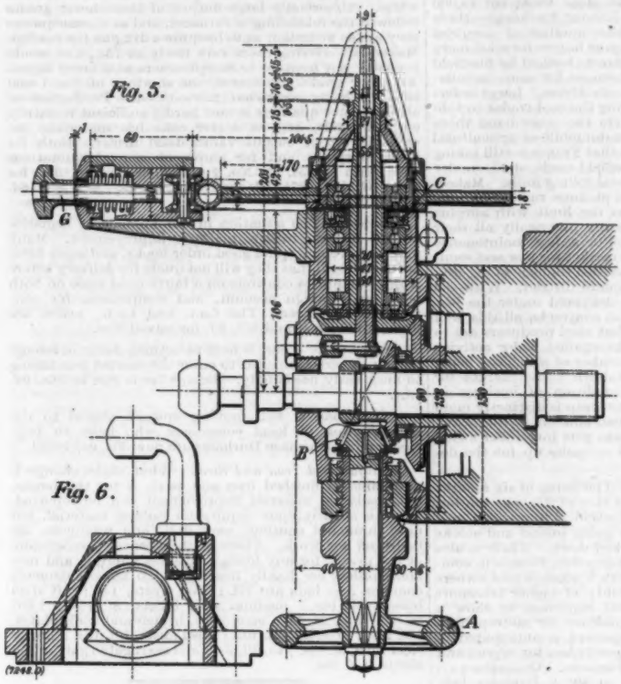


Fig. 6.

Fig. 7.

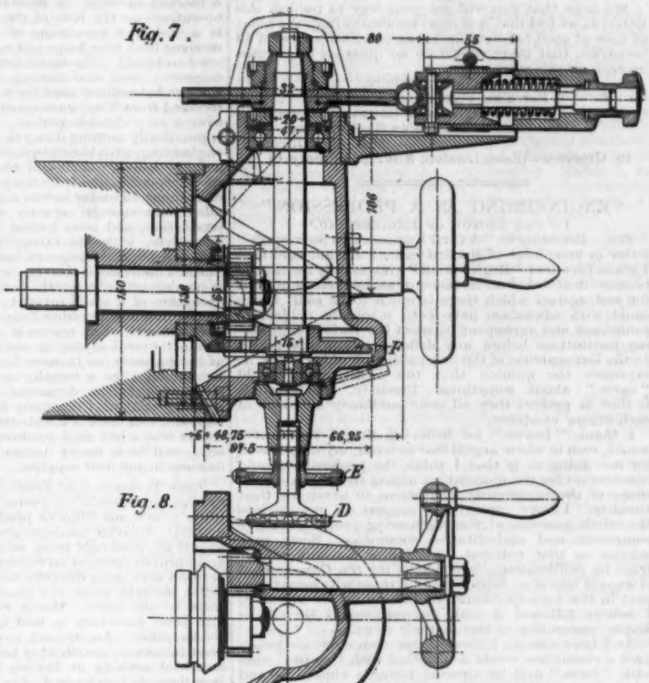


Fig. 8.

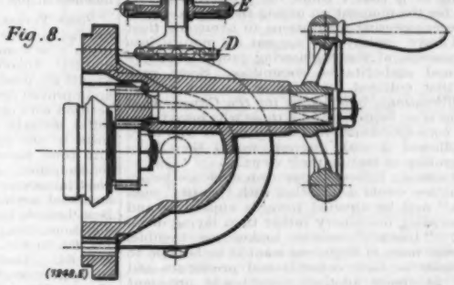
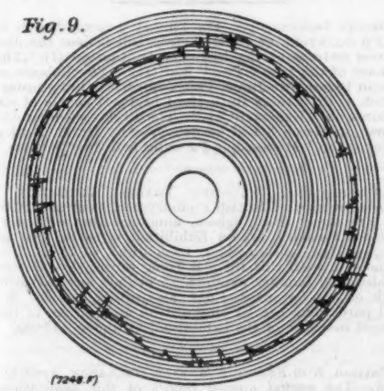


Fig. 9.



and the pen also takes up its mean position on the chart. Any irregularity in the speed ratio of the gears being tested, will cause the finger to move the pointer slightly as the two rotate together and will also cause the pen to move radially over the chart. Fig. 9 illustrates a chart drawn automatically in the manner described, by a pair of hardened bevel wheels made by Messrs. Saurer. The original chart was 3¼ in. in diameter, and the circles, 1 mm. apart, corresponded to a magnification of 100 times the relative motion of the friction discs. The wheels under test were a seven-tooth pinion gearing into a 55-tooth wheel, the pitch being 25 mm. at the outer diameter. Such wheels are used for the back axle drive of the Saurer 5-ton lorry, with a 40-b.h.p. engine, and in spite of the boldness of the design, we believe they have given excellent service.

For testing the straightness and angle of individual teeth, the gauge shown in Fig. 2 is employed. A ball-ended column fitting into a conical seating in the bed, is permanently located so that the centre of the ball exactly coincides with the intersection of the axes of any bevel wheels which may be tested. A hardened steel gauge has near one end a conical cup, which fits over the ball, and a true straight edge is formed along part of the side of the gauge. The straight edge points exactly to the centre of the ball, so that by using the gauge as indicated in the illustration any defect in the points or flanks of the teeth may be observed.

The operation of the machine is quite simple and needs no more care or knowledge than a good tool-room mechanic would possess. It is specially intended for the testing of gear wheels for motor vehicles, and will take gears up to about 18 in. diameter.

"POWER STATION ECONOMY IN GREAT BRITAIN."

TO THE EDITOR OF ENGINEERING.

SIR,—I notice that in your comment on the Electricity Commissioners' recently published report on the above subject, you, on page 176 of your February 10, 1922, issue, quote from my remarks in the discussion of Mr. Baumann's paper at the Institution of Electrical Engineers in April last. You have evidently misspelt my name as J. N. Thwaite.

The actual overall thermal efficiency of 25·87 per cent. you quote was the second highest for the five Carville turbo-alternators, the highest being 25·96 per cent. The actual test figures for the five 10,000 turbo-alternators at Carville are given on page 656, vol. lix, Journal of the Institution of Electrical Engineers.

Yours faithfully,

February 17, 1922. J. N. WAITE.

"PYROMETRIC PRACTICE."

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Paul D. Foote, of the Bureau of Standards, Washington, has drawn our attention to the fact that he and his colleague, Mr. Harrison, worked out and published an arrangement for correcting for the resistance in the leads and the temperature coefficient of the galvanometer used with a thermocouple and leads, similar to the instrument described by you on page 19 of your number of January 6, 1922, in the article describing our exhibit of instruments at the Physical and Optical Societies' Exhibition.

We admit frankly that the arrangement described is similar to that of Mr. Foote and Mr. Harrison, but in doing so we feel that we should like to be allowed to state exactly what occurred.

In *Chemical and Metallurgical Engineering*, of September 1, 1919, an article appeared on "A New Compensated Heatmeter" by Mr. Charles P. Frey, of the Brown Instrument Company, Philadelphia, describing the arrangement of Mr. Foote and Mr. Harrison as a method for compensating for the lead resistance of a thermocouple circuit, but no mention was made of the possibility by proper selection of the different resistances of correcting for the errors introduced by temperature on the instrument, these errors including the change in resistance of the coil in the instrument, the magnetic flux of the magnet, &c.

Mr. F. Rowcliffe, who was then in charge of our test room, read the article, and it occurred to him that by an addition to the formulæ the arrangement could be made to correct for these latter errors. As a result of his work it was decided to patent the idea, and application was made for a patent on April 15, 1920. The patent (No. 164,916) being accepted on June 23, 1921.

When application was made for the patent our patent agents were clearly instructed as to the work done by Messrs. Foote and Harrison; the following is a copy of our claims:—

"1. A method of compensating the temperature coefficient of a galvanometer or the like used in a circuit including a thermo-electric couple for the determination of temperatures, by so selecting the ohmic value of a fixed series resistance and of a fixed shunt resistance adapted for alternative connection in the circuit including the galvanometer and an adjustable series resistance, that the temperature coefficient of the galvanometer, as well as the remainder of the circuit, is compensated by suitably setting the adjustable series resistance.

"2. The device for compensating the temperature coefficient of a circuit including a galvanometer or the like and a thermo-electric couple for the determination of temperatures, substantially as described and illustrated in the accompanying drawing."

From this it will be seen that our claims were for the method of correcting for the effect of temperature on the galvanometer, and that no mention is made of the lead resistance.

Except for the article above-mentioned, we did not know anything of the papers published by Messrs. Foote and Harrison until we received the Technologic paper No. 170 from the Bureau of Standards, on "Pyrometric Practice," by Messrs. Foote, Fairchild and Harrison, nor did we know that Messrs. Foote and Harrison had extended their work to cover the correction of the temperature coefficients of the instruments.

The paper by Messrs. Harrison and Foote, "A Precision Galvanometric Instrument for Measuring Thermo-Electric Electromotive Forces," read at the Convention of the American Institute of Electrical Engineers on February 20, 1920, had not been seen by any of our staff until two or three weeks ago. The technologic paper of the Bureau of Standards referred to was first seen by us in October, 1921.

We understand that Messrs. Foote and Harrison believe that we have pirated their idea, and we can only state as we have done in the earlier part of our letter that our improvement was suggested by their work, but we thought we were in possession of an improvement of the same.

We realise, now, that they were aware of, and had published, this further development at an earlier date than that of our patent, and that our patent is invalid. We regret that as soon as we received the technologic paper from the Bureau of Standards we did not at once write to Mr. Foote pointing out that our work on the

temperature coefficient of the instrument had been done quite independently of his. We feel that we owe him and his colleague an apology, and we submit this to them herewith.

Up to the present we have sold only one instrument, which has not yet been supplied.

We hope that you will see your way to publish this letter, as we feel that it is most important from the point of view of good relationship between scientific men in all countries, that there should be no question of trespass on each other's work.

Yours faithfully,
For The Cambridge and Paul Instrument Company, Limited,
Robert S. Whipple,
Joint Managing Director.
45, Grosvenor-place, London, S.W. 1, February 18.

"ENGINEERING AS A PROFESSION."

To the Editor of Engineering.

Sir,—Referring to "A Civil Engineer and Surveyor's" letter in your issue of the 3rd inst., I am not sure that I am in favour of "Registration"; it was only mentioned because it afforded an instance of an important matter, for and against which there is much to be said, which could with advantage have been made the subject of conference and agreement between the various engineering institutions before any definite action was taken. In the last sentence of the first paragraph of his letter, he expresses the opinion that the Institutions should "agree" about something. Precisely. The trouble is that at present they all seem sublimely oblivious of each others' existence.

I thank "Icarus" for believing that I could, if I would, rush in where angels fear to tread, my only reason for not doing so is that I think the profession should concentrate for the moment on urging the angels, in the shape of the engineering institutions to overcome their timidity. I have ventured to suggest an inquiry into the whole position of the engineering profession, by a competent and authoritative committee. Some such scheme as that outlined by "Icarus" might emerge from its deliberations, but that is for the future, what is wanted *now* is an investigation; those who have taken part in this correspondence, and many others who have I believe followed it with interest, would then have ample opportunity of stating their views.

As I have already indicated, my own evidence before such a committee would deal rather with "spirit" than with "form," and be directed towards improving and lubricating existing machinery rather than laying down more of it. "Icarus'" scheme makes me tremble. What the great mass of engineers want is to be able to get a bit closer to their councils and presidents and secretaries; to create another council and president and secretary even more august and remote than the present ones hardly appeals to me as a step in the right direction.

Yours faithfully,
"Nabla."

"BALL AND ROLLER BEARINGS: THEIR DESIGN AND PERFORMANCE."

To the Editor of Engineering.

Sir,—The question raised by Mr. R. Orsettich as to the relation between the radial and axial loads that may be applied to ball bearings is easier to answer for single-row journal bearings than for the double row radial bearings referred to by Mr. Macaulay (Engineering, January 20).

If for the first approximation we consider the effect of load alone, apart from friction, investigation shows that for the latter type the relation in question is a function of the angle subtended at the geometric centre of the bearing by the line joining the ball centres (*loc. cit.*, Figs. 1 and 2, in your issue of January 10, page 87). If the cotangent of half this angle be multiplied by two-fifths of the side thrust the result is the equivalent radial load. This angle varies in the type in question, and the coefficient converting thrust into radial load varies accordingly (from 3 to 9, *loc. cit.*). The permissible axial load when running is less than this because all axial loads introduce spinning effects.

In the single-row type the position taken up by the balls does not depend upon the dimensions of the bearing; and the angle is one which permits of the same side thrust being carried with less radial effect. As to the magnitude of the axial load which can be sustained, in a contribution which the writer had the honour to make to the Institute of Automobile Engineers' Proceedings, 1921, page 569 *et seq.*, Rudge-Whitworth bearings of various sizes were run without damage under steady loads and speeds complying with the formula:

$$(1 \cdot 5) \times \text{Listed Radial Load} = \text{Radial Load} + (4 \times \text{Axial Load}).$$

During the discussion instances of the use of single-row annular bearings were mentioned under quite considerable side thrust. Under normal conditions the formula:

$$\text{Listed radial load} = \text{Radial load} + (4 \times \text{Axial load}),$$

may safely be used for bearings of our manufacture.

Quoting the example of Mr. Orsettich, if the bearing can carry a 1,000 lb. radial load, as given in catalogue, and if the actual load is only 800 lb., then the axial load which can be sustained is a quarter of the difference, viz., 50 lb.

Yours faithfully,
For Rudge-Whitworth, Ltd.,
Henry L. Heathcote,
Chief of Research Laboratories.
Bearing Works, Reddings-lane, Sparkhill, Birmingham, February 17, 1922.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—There is a marked division of opinion as to the immediate outlook in the local heavy trades. Although as a whole unemployment in the district shows a marked increase—in Sheffield alone there are 49,000 operatives on the lists of the Labour Exchange—there is a welcome expansion in the number of inquiries received both from home and export buyers for machinery steel and tools. The latest contracts booked by Sheffield engineers cover steel-making furnaces for some installation, and structural steel for South Africa. Large orders received from Russia are assisting the tool trades to tide over a very difficult period. On the other hand there is practically nothing doing in automobile or agricultural engineering, with the exception that France is still taking a fairly heavy tonnage of Sheffield-made steel under special specification from the local rolling mills. Makers of commercial motor lorries and pleasure runabouts have filled their storage capacity to the limit with surplus production, and have turned away practically all their operatives, with the exception of a few maintenance men. A hopeful feature in the market for raw and semi-finished materials is that an increased tonnage of pig-iron is coming into the South Yorkshire district. With the exception of a small quantity delivered under the last placed and now expiring Belgian contracts, all this is of British make. The reason is that steel producers are to a minor extent laying in stocks against wider activity at the furnaces, an increased number of which are being lighted up after a lengthy set-down. The market for alloys reflects the depressed condition of business in special steels, but the inquiry for scrap is distinctly more buoyant, and there is a widespread opinion in the heavy trades that when steel production gets into fuller swing scrap will be in heavy demand to make up for the deficiency in pig-iron supplies.

South Yorkshire Coal Trade.—The fixing of six months railway contracts at an average rate of 21*s.* per ton has given a welcome fillip to production in the steam coal market. Heavier tonnages are going inland and stocks at pits are gradually being worked down. There is also an improved demand on export account, though in competition with other districts South Yorkshire coal owners suffer severely under the disability of higher transport costs to the coast. House coal continues to show a firm tone, especially in best qualities for metropolitan consumption. An upward movement is anticipated in blast furnace coke following larger orders for export and increased activity at British furnaces. Quotations:—Best branch handpicked, 38*s.* to 39*s.*; Barnsley best Silkstone, 36*s.* to 37*s.* 6*d.*; Derbyshire best brights, 24*s.* 6*d.* to 35*s.* 6*d.*; Derbyshire best house, 33*s.* 6*d.* to 34*s.* 6*d.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 24*s.* to 25*s.* 6*d.*; Yorkshire hards, 27*s.* to 28*s.*; Derbyshire hards, 26*s.* to 27*s.*; rough slacks, 14*s.* to 15*s.*; nutty slacks, 11*s.* 6*d.* to 13*s.*; smalls, 2*s.* 6*d.* to 6*s.* 6*d.*

Personal.—Messrs. The Kitson Empire Lighting Company, Limited, Stamford (Lincs.), state that with the authorisation of the Board of Trade they are changing the name of their company to that of the Kitson Engineering Company (London), Limited. It is their intention to carry on the same business as previously. They are adding one or two other branches to their business, such as the manufacture of the Kitson-Utley rotary lamp, and propose to engage in a general engineering business. They have opened London offices with showrooms at No. 1, Central Buildings, Westminster, S.W. 1.

"Vibrac" Steel.—The announcement is made that Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, following upon researches carried out at their Openshaw Works, Manchester, by Mr. H. H. Ashdown and other experimentalists, have discovered a new steel, styled "Vibrac" steel, which, it is claimed, gets over the temper-brittleness of nickel-chromium steels, a difficulty which has formed the subject of recent papers presented to the Iron and Steel Institute. In great masses it is said to be consistent throughout; it is also highly resistant to torsion and shock, qualities which render it very valuable for turbine rotors and shafts, crankshafts, and all machinery component parts which are stressed to a high degree when running at high speeds.

Brazilian Centenary Exhibition.—On December 28 the Prefect of Rio de Janeiro laid the foundation stone of the Pavilion which is being built for the accommodation of British exhibits at the forthcoming Brazilian Centenary Exhibition. The exhibition, to be open from September 7 to December 31, 1922, will be universal and international, and is being organised by the Brazilian Government in connection with the celebration of the centenary of Brazilian Independence. Invitations to participate have been accepted by most of the leading Powers, and our chief competitors in the Brazilian market are making great efforts to further their interests by taking full advantage of the opportunity which the exhibition offers for trade propaganda and advertisement. The United States of America have voted a million dollars for official participation, while the Belgian Government, in addition to a National Pavilion, intend to build an exhibition hall having an area of 70,000 square feet, and there is every indication that other countries intend to be very strongly represented. In view of the activities of other countries it is, therefore, essential that the British section should be thoroughly representative. Full information and particulars regarding rates for space can be obtained from the Department of Overseas Trade, 35, Old Queen-street, S.W. 1., who have issued particulars and plans of the British Section.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The only descriptions of Cleveland pig-iron that are plentiful are mottled and white. Abnormally large output of these lower grades followed the rekindling of furnaces, and as a consequence they are so abundant as to be quite a drug on the market. Makers are offering them very freely at 75*s.*, and would probably not hesitate to accept orders at a lower figure. All other grades are scarce, the shortage of No. 1 and siliceous being somewhat pronounced. Production of all the better qualities is now hardly sufficient to satisfy current needs, and as dearer coke has materially increased cost of output values tend firmer. Both for home purposes and for shipment abroad quotations stand firm at 95*s.* for No. 1 and siliceous iron, 90*s.* for No. 3 G.M.B., 87*s.* 6*d.* for No. 4 foundry, and 82*s.* 6*d.* for No. 4 forge.

Hematite.—The situation in the East Coast hematite branch shows rather marked improvement. Many makers have now quite good order books, and some firms are so well sold that they will not quote for delivery before April. Inquiries continue on a fairly good scale on both home and foreign account, and competition for contracts is less keen. The f.o.t. and f.o.b. prices are 98*s.* 6*d.* for No. 1 and 97*s.* 6*d.* for mixed Nos.

Foreign Ore.—There is next to nothing doing in foreign ore, customers compelled to enter the market purchasing to meet early needs only. Best rubio is 26*s.* to 26*s.* 6*d.* c.i.f.

Coke.—Coke is still moving upward almost to the consternation of local consumers who have to buy. Medium blast-furnace Durhams are now 30*s.* delivered.

Manufactured Iron and Steel.—What slight change is noticeable in finished iron and steel, is for the better, but really no material improvement can be reported. There is slightly more inquiry for railway material, but most branches continue very dull, and producers are badly off for work. There is the keenest competition, at cut prices, for any foreign business offering, and new home orders are hardly heard of. To home customers common iron bars are 12*l.*; iron rivets, 14*l.*; soft steel billets, 7*l.* 10*s.*; medium steel billets, 8*l.* 15*s.*; hard steel billets, 9*l.* 5*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; to 10*l.* 5*s.*; and corrugated galvanised sheets, 15*l.* 10*s.*

Royal Institution.—On Thursday next, March 2, at 3 p.m., Professor H. M. Lefroy will deliver the first of two lectures at the Royal Institution on (I) "The Menace of the Insect Pest" and (II) "The Balance of Life in Relation to Insect Pest Control." On Saturday, March 4, Sir Ernest Rutherford begins a course of six lectures on "Radioactivity." The Friday evening discourse on March 3 will be delivered by Dr. C. Morley Wenyon, on "Microscopic Parasites and their Carriers."

International Foundry Trades Exhibition.—The Institution of British Foundrymen, Central House, 75, New-street, Birmingham, announce that an International Foundry Trades Exhibition is to be held at Bingley Hall, Birmingham, from June 15 to 24. In connection with this there is being arranged a section of historical foundry exhibits, to include any cast-iron work or non-ferrous castings, also prints, models, &c. Full particulars can be obtained on application to the general manager of the exhibition, at above address.

British Non-Ferrous Metals Research Association.—The second annual report of this association, for the year ending December 31 last, gives evidence of the useful work it is carrying out. The membership exceeds one hundred firms, distributed all over the country and including both manufacturers and users of non-ferrous metals. Among the investigations being conducted may be mentioned those on brass casting, on the influence of impurities on the working properties of copper, on metal polishing and grinding, on the jointing of metals, the electric melting of non-ferrous metals, &c. On the other hand, the association is performing an important public service in continuing its work on the atmospheric corrosion of non-ferrous metals.

Safety Fuel Tanks for Aeroplanes.—The last stage in the Air Ministry competition trials of safety petrol tanks for aircraft was reached this week, when the three tanks selected by preliminary trials from among the 26 entries received were finally tested at Farnborough on Monday and Wednesday last. The three tanks selected for the final trials were the "Boothby" gas-armoured tank, submitted by Commander F. L. M. Boothby, the "Imber" self-sealing tank submitted by Messrs. Imber Anti-Fire Tanks, Limited, and a tank submitted by the India Rubber, Gutta Percha and Telegraph Works Company, Limited. Crashing tests, similar to those in the preliminary trials referred to on page 769 of our last volume, were carried out on Monday, and, in addition, some special tests were made to determine the resistance of the tanks to the effects of acceleration. In the firing tests, which were made on Wednesday, the tanks were subjected to machine-gun fire with ammunition capable of penetrating the ordinary type of mild steel fuel tank and of exploding and igniting the fuel either on contact or after penetration. The results of the trials and the names of the prize winners will be announced later.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel industry have shown little variation of late, and to all appearances there would seem to be small prospect of an early revival of trade. Home buyers are still keeping out of the market evidently in the hope that Continental quotations will cause local prices to be brought down again to meet the competition. There is not much chance of that taking place in the meantime even should cost of production ease off a bit, because the prospect of that was taken into account when prices were fixed recently, and to-day's selling rates show practically no margin of profit. On the export side of the trade there has been little development, although quite a number of inquiries have been passed through lately. The demand for plates, &c., from shipbuilders is very poor, as there are so few contracts on hand, but immediately after prices become easier again there are indications that some owners are likely to order new tonnage. The black sheet makers report no improvement in trade, and the reductions which recently took place in prices have not brought out much new business. Galvanised sorts are the turn better. The following are the current prices: Boiler plates, 14*l.* per ton; ship plates, 10*l.* 10*s.* per ton; sections, 10*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—In the West of Scotland malleable iron trade there has been little movement during the past week, and the various works are all more or less extremely quiet. Orders are not coming forward in anything like the volume anticipated after the last fall in prices, and employment at the works is not very satisfactory. As in the allied trades the "wait and see" policy is being followed by buyers, many of whom, however, have little business to give out. "Crown" bars are quoted at 11*l.* 10*s.* per ton.

Scottish Pig-Iron Trade.—There has been almost no change in the Scottish pig-iron trade over the week, and buyers continue to place orders for immediate requirements only, and forward buying is very small indeed. Export business is also very poor. Prices are a shade easier and consumers are quite expecting lower quotations after the concessions as regards freight on ore, &c., on the railways, come into force. The following are the current prices: Foundry iron, No. 1, 5*l.* 5*s.* per ton; and No. 3, 5*l.* per ton, loaded into trucks at maker's works. Hematite is called 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works.

THE NEW SPANISH TARIFF.—A complete translation of the new Spanish tariff has been prepared by the Board of Trade and has been issued as a supplement to the *Board of Trade Journal*, of yesterday, the 23rd inst. This tariff became fully operative on the 16th inst.

BURNERS FOR BLAST-FURNACE GAS.—The results of some comparative tests of blast-furnace gas burners for boilers and for Cowper furnaces are published by E. Weymann, of Dortmund, in *Stahl und Eisen* of February 9, pages 215 to 221. All the boilers had a heating surface of 90 sq. m. and were connected to the same feed water heater. Of the various burners tried, those of Terbeck, Moll and Eickworth were submitted to the longest series of tests. The two first-mentioned burners are of the Bunsen type. In the Terbeck burner the gas passes from a ring-shaped nozzle into the wide end of a conical mixing tube; the Moll burner has several gas nozzles and mixing tubes. In the Eickworth burner both gas and air pass through the same ring nozzle; this ring is subdivided into alternating air and gas chambers, and in front of the nozzle rotates a bucket wheel which thoroughly mixes the two constituents. It was found that the object of obtaining the highest temperature in the smallest space with the shortest flame was best attained with the Eickworth burner, which was especially superior to the Bunsen type with respect to its ability to maintain efficient combustion in spite of fluctuations in the gas pressure. In the Cowper furnace tests of blast preheaters Dingler burners and some American arrangements were also tried.

THE LATE PROFESSOR F. HENNINGS.—In the death of Dr. Fritz Hennings, Professor of Railway Construction at the Zürich Technical High School, on February 2, Swiss engineers have lost one of the most original and successful pioneers in mountain railway work. Born at Kiel, in Holstein, in 1838, Hennings attained the considerable age of 83 years. He came to Zürich as a student of the Polytechnicum, in 1859, and was, on obtaining his diploma in 1861, at once engaged in railway engineering on the Zürich-Zug-Luzern line. Similar appointments took him later to Würtemburg, to various parts of the Austrian Alps and then back again to Switzerland where he made a name especially in connection with the southern section of the St. Gotthard Railway. After having spent a few more years on the Munkacs-Beszkid line in the Carpathians, he returned finally to Switzerland in 1890. Having for six years been the principal assistant of the chief engineer, R. Moser, he was in 1898 entrusted with the construction of the Albula line of the Rhätische Bahn. There he did excellent work, both as an engineer and administrator, and was fortunate also in difficult and involved legal negotiations. In 1903 he was appointed successor to his colleague of the St. Gotthard Railway days, Gerlich, as professor for railway construction; he held this appointment until a year ago. His sterling character contributed much to his great popularity.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—A complete change has taken place in the coal market during the past week. Prices are now firm in every section, except in respect to anthracite coals, and the demand exceeds the supply. The change is partly due to reduced outputs in consequence of the influenza epidemic and partly to the new policy of salesmen under which each day consultative action is taken with a view to keeping prices at an economic level. Practically all collieries are fully booked up for this month, and in many cases well into March. On the other hand, buyers who had been holding off hoping for further reductions have come on for their immediate supplies. Prices have jumped from 6*d.* to 1*s.* 6*d.* per ton and are firmly maintained at the new levels. For instance, best Admiralty large now commands 26*s.* to 26*s.* 6*d.* compared with 25*s.* to 25*s.* 6*d.* a week ago, seconds 25*s.* 6*d.* to 26*s.* against 24*s.* 6*d.*, best dry large 25*s.* 6*d.* to 26*s.* against 24*s.* to 24*s.* 6*d.*, and the leading Monmouthshires from 25*s.* to 25*s.* 6*d.* against 23*s.* 6*d.* to 24*s.* 6*d.* Steam smalls have also developed increased strength. For some time past these have been scarce and commanded relatively high prices when compared with large, whereas a week ago it was possible to secure a discount of 1*s.* to 1*s.* 6*d.* in the price of smalls when taken in conjunction with large; sellers now indicate the same figure whether large is taken or not. Best steam smalls command from 19*s.* 6*d.* to 20*s.*, with seconds from 18*s.* 6*d.* to 19*s.*, and ordinaries from 16*s.* to 17*s.*, while best drys realise up to 15*s.* Sized coals are practically unobtainable, but bituminous nuts are nominally quoted at 27*s.* 6*d.* to 28*s.* 6*d.* and beans at 25*s.* to 26*s.* In January the average f.o.b. declared price of large steam coals shipped from Cardiff was 26*s.* 10*d.* per ton, which was the same as in December, but 3*l.* 12*s.* 4*d.* below the average for September, 1920. Steam smalls exported from Cardiff last month averaged 16*s.* 11*d.*, compared with 17*s.* 4*d.* in December and 80*s.* 1*d.* in September, 1920. In January, 1913, it is interesting to note the average price of steam large was 16*s.* 8*d.*, and of small 10*s.* 8*d.* Foreign cargo exports from South Wales in January totalled 1,858,000 tons, or 12,000 tons more than in December. Shipments to France amounted to 627,000 tons, Italy 302,000 tons, South America 200,000 tons, Spain 115,000 tons, Portugal 62,000 tons, Greece 44,000 tons, British coaling depots 157,000 tons, and other countries 352,000 tons.

Shipping Firm's Big Loss.—The accounts of the Westville Shipping Company, Limited, Cardiff, covering the company's second year, which ended on September 30 last, shows a trading loss of 7,013*l.*, to which must be added bank interest, taxation, charges, &c., making a total loss of 31,471*l.* During the year the company's steamer Shoreham was laid up for 10 weeks, the Polly Bridge for 26 weeks, and the Avanville for 14 weeks. These vessels which aggregate 2,300 tons, stand in the balance sheet at 148,400*l.*, or over 63*l.* per ton, while there are loans for nearly 99,000*l.* The company has appealed to shareholders to subscribe to an issue of 10 per cent. cumulative preference shares of 2*s.* 6*d.* each.

OLD LONDON BRIDGE.—The proposal to remove the ancient arch recently discovered under London Bridge is viewed with regret by many professional societies and other bodies, some of whom have tried, unsuccessfully, to oppose the proposed removal. The Concrete Institute are credibly informed that the cost of preserving this ancient relic of London of very many centuries ago would amount to 7,000*l.*; and with a view to further effort being made towards its preservation, the Institute has called together a joint conference of all the professional societies, city companies and others interested, the first meeting of which will be held at the offices of the Institute (Denison House, Vauxhall Bridge-road, S.W.) on Monday next, the 27th inst., at 5.30 p.m. It is believed that there are various funds which might be utilised for the purpose in hand, which all Londoners will agree is deserving of every support.

THE ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT.—Interesting statements were made at the general meeting of the Allgemeine Elektricitäts Gesellschaft, when it was unanimously decided to increase the capital by a maximum of 250,000,000 marks, whereby the capital is raised to 1,100,000,000 marks. Complaints were made to the effect that the dividend, in spite of the eminently satisfactory year, was only increased by 2 per cent., although the bank balances had risen from 26,000,000 marks to 658,000,000 marks; also to the effect that the reserves had increased 300 per cent., now amounting to 288,000,000 marks, whilst the percentage of profits had been doubled and the sums set aside for welfare institutions nearly so. It was also argued that the "still reserves" of the company, the raw materials, half finished and finished goods were only booked at about one quarter of their actual value; the holdings in other concerns represented a further reserve of some 435,000,000 marks above their booked figures. It was pointed out by the Board that this was in perfect harmony with the policy of the company, also that machines, tools, models, &c., had been written down to 1 mark and that buildings and land figured at reduced sums. The "still reserves" proceeded from exchange transactions which had been undertaken to strengthen the position of the company and secure an increased number of customers. The business policy of the Board was to prepare for the future. The increase of capital was said to be necessary so as to enable the company to make fresh favourable exchange or interchange transactions. The shareholders might rest assured, it was added, that the Board would manage the company according to sound principles.

NOTICES OF MEETINGS.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Saturday, February 25, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. 4. Informal discussion on "Mechanical Stokers *v.* Hand Firing, both with Forced Draught."

INSTITUTION OF MECHANICAL ENGINEERS.—Monday, February 27, at 7 p.m., at Storey's Gate, St. James' Park, S.W. 1. Annual Graduates' Lecture to be delivered by Sir Henry Fowler, K.B.E., on "Metallurgy in Relation to Mechanical Engineering." All classes are invited.

THE ROYAL SOCIETY OF ARTS.—Monday, February 27, at 8 p.m.: Cantor Lecture, "The Mechanical Design of Scientific Instruments," by Professor Alan F. C. Pollard, A.M.I.E.E., F.Inst.P., Department of Optical Engineering, Imperial College of Science and Technology, South Kensington. (Lecture II.) Wednesday, March 1, at 8 p.m.: Ordinary Meeting, "The Duplex-Coupler Pianoforte," by Mr. Emanuel Moor. Mr. Percy A. Scholes, Music Critic of *The Observer*, will preside.

THE INSTITUTE OF MARINE ENGINEERS, INCORPORATED.—Tuesday, February 28, at 6.30 p.m., "Combined Internal Combustion and Compressed Air Engine," by Mr. R. W. Robinson. (Postponed from February 7.)

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, February 28, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, when a discussion on "Industrial Lighting; Ideal Requirements (Legislative and Otherwise) and Practical Solutions" will be opened by Mr. L. Gaster.

THE NEWCOMEN SOCIETY.—Wednesday, March 1, at 5 p.m., at Caxton Hall, Westminster, S.W., paper by Mr. Robert Young, M.I.Mech.E., Member, on "Timothy Hackworth and the Locomotive."

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION MEETING.—Wednesday, March 1, at 6 p.m. in the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. "The Thermionic Triode as Rectifier," by Mr. E. B. Moullin and Mr. L. B. Turner (Member).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 3, at 8 p.m., at Caxton Hall. Lecturette, "Factory Administration," by Mr. Edward T. Elbourne.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 3, at 7 p.m. Informal Meeting, "Spiral Bevel *v.* Straight-Tooth Bevel," by Mr. A. P. Bale (Associate Member).

THE INSTITUTION OF PROFESSIONAL CIVIL SERVANTS.—Sir Richard Redmayne, K.C.B., will deliver the presidential address at the first annual general meeting of the members of the Institution of Professional Civil Servants, to be held in the Large Gallery, Royal Institute of British Architects, 9, Conduit-street, W.1., on Tuesday, March 21, 1922, at 6 p.m.

SWEDISH IRON.—The report of the Union of Swedish Ironmasters states that 1921 was an exceedingly bad year for the Swedish iron industry. The production receded to 308,000 tons of pig-iron, 230,000 tons of blooms and ingots, 122,900 tons of rolled and hammered iron, which figures represent less than half of the production in 1913. The exports fell to 147,000 tons and the home sales were very unsatisfactory. At their last meeting, the Union of Swedish Ironmasters reduced their quotations all round.

NEW STEEL FOR DRILLS.—According to *Canadian Machinery*, a new form of steel has been developed by the Cleveland Twist Drill Company, Cleveland, Ohio. This steel is to be used in the manufacture of their drills, and such drills are to be known under the trade name of "Mezzo." Speaking on the new steel, the Cleveland Company say that it possesses some very unusual qualities, and these are the result of a special heat treatment. The word "Mezzo" is intended to convey the meaning, midway between carbon and high-speed steel. Drills made from this material are said to be well adapted for drilling cast-iron at greater speeds and feeds than can be used for carbon drills. They will also speed up work on machine steels and the softer alloy steels, but are not recommended for use in extremely hard materials. These drills should be operated at approximately double the speed of carbon drills. They are not intended to supersede high-speed drills, but rather to furnish a type midway between the two extremes.

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION.—The annual general meeting of the British Electrical and Allied Industries Research Association was held on the 3rd inst., at the Institution of Electrical Engineers. Mr. W. O. Smith, chairman, and Mr. D. H. Dunlop thanked Mr. Wordingham for his indefatigable interest and assistance in all the work of the association. They also explained their indebtedness to the firms who had allowed members of their staffs to give so much time to that work. Whilst a good beginning had been made, and manufacturers had agreed to find 8,000*l.* per annum for co-operative research for five years, for the benefit of all concerned with the electrical industry, it was becoming exceedingly difficult to find money for such purposes whilst orders were being placed with foreign competitors. He thought that purchasers did not properly appreciate what British manufacturers were doing to advance the common interests, and how difficult the position was owing to international exchanges and foreign competition.

THE TURBINES AND DOUBLE-REDUCTION GEARING FOR THE T.-S.S. "CONTE ROSSO."

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, DALMUIR.

(*For Description, see Page 223.*)

FIG. 59. STARBOARD SET OF TURBINES AND GEARING DURING ERECTION.

ENGINEERING.

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ENGINEERING.

FRIDAY, FEBRUARY 24, 1922.

OUR ELECTRICAL HERITAGE.

THOSE who call for the endowment of abstract or pure research could hardly find a better text from which to argue than is afforded by the results which have flowed from the work done by Michael Faraday round about the year 1832, in the laboratory of the Royal Institution. The lady—it is the custom to regard electricity as of the female sex—whose wiles and moods Faraday investigated and reduced to rule with a few simple bits of wire and pieces of iron shows fair intention at no distant period of becoming the mistress of every branch of engineering. It is far from our present purpose to argue the merits of pure, as against what one may call industrial, research, but the widespread practical ends to which the work of Faraday has led induces the speculation that the amazing advance of electrical engineering may partly be explained by its direct derivation from pure science.

Electrical engineering more than any other branch of engineering is based on definite scientific fact, or more correctly definite scientific measurement. This condition has proved to be of enormous commercial value, since the problems with which the electrical engineer has to deal have a clarity and definiteness which are not shared by the problems which have to be faced by workers in other engineering spheres. Electrical engineering has some of the simplicity of chemistry, and while in the year 1922 there is still much room for difference of opinion about what happens inside a steam engine, or oil engine cylinder, there is none for what happens inside a transformer or electric motor. Saying this we, of course, refer to the immediate and tangible happenings which affect output and efficiency.

The ultimate molecular happenings may in both cases have practical bearing in the future. At present they have none, except perhaps in wireless telegraphy, and that commercial efficiency is some measure of scientific knowledge is accentuated by the fact that in this branch of electrical engineering, where we are but yet groping, the efficiency is lowest. This direct connection between scientific measurement and commercial efficiency is perhaps difficult to illustrate directly, but it is very conceivable that had the efficiency of conversion of electric to mechanical energy of the best electric motor been of the order of, say, 5 per cent., then the electric motor would not have attained the position it has. It is because the internal losses of such electrical machinery can be measured so accurately that they have been developed to their present pitch of efficiency, and the possibility of this accurate measurement is based directly on Faraday's work on electro-magnetic induction. This work and its effect gives Faraday a peculiar position in electrical engineering. Steam engineering has its Newton, but it is no reflection on Newton's great work to say that his contribution was certain motions, certain facts if one wishes, but not certain definitely measured facts. His successors have taken things but little further. Faraday, on the other hand, contributed facts which have lent themselves to application with scientific accuracy, and as a result one has to-day electrical machines with an efficiency which is not approached by the machines of any other sphere of human endeavour.

It may be argued with much justice that Faraday was working in a simpler field than Newton, but into matters of that kind we need not now enter. The important fact for the moment is that Faraday in a very special sense was the founder of electrical engineering, and it was fitting and graceful that the Commemoration Meetings which marked the jubilee of the Institution of Electrical Engineers should have opened with a lecture on his work. These meetings were held in the Institution building on Tuesday, Wednesday and Thursday of this week, the opening lecture on "Michael Faraday and the Foundations of Electrical Engineering" being delivered on Wednesday afternoon by Professor Fleming. The major part of the lecture was devoted to Faraday's work on electromagnetic induction, but his investigations on di-electrics and electro-chemistry were also touched on. Professor Fleming re-performed many of Faraday's experiments and also exhibited much of his original apparatus from the Royal Institution.

It is needless to attempt a formal report of the lecture, which was accompanied by experiments throughout, since one may trust that the foundation electromagnetic phenomena are generally familiar to engineering readers. The lecture was none the less of very considerable interest, and if it took some of us no further back than our student days, it was a unique pleasure to hear Sir Herbert Jekyll's personal recollections of Faraday's juvenile Christmas lectures at the Royal Institution. Sir Herbert is, we believe, one of the two surviving foundation members of the Society of Telegraph Engineers of which the present Institution of Electrical Engineers is the development. His account of Faraday's lectures added emphasis to Dr. Fleming's plea for a more general support of the Royal Institution. Dr. Fleming quoted the figure of 100,000*l.* as the total cost of all the experimental work carried out at the Royal Institution since the beginning of the nineteenth century. This figure spread over 120 years amounts to but a meagre annual sum, and if Dr. Fleming's lecture results in a more general appreciation of what science and industry owes to the Institution in Albemarle-street then it may directly help forward the good work which it has done and is doing.

As the inheritors of the work of Faraday the Institution of Electrical Engineers owes more to the Royal Institution than is perhaps always realised, and although as an institution it perhaps could not easily assist the older body, it none the less has many members who could personally assist by becoming members of the other institution also. We have no wish, however, to suggest that the Institution of Electrical Engineers is unconscious or negligent of its fair heritage. In activity and energy it stands among the first technical institutions of the country, but in its progress and continual adaption to the conditions of a changing world it does not lose sight of the past and the work of the past. This is incidentally well illustrated by the form which the commemoration meetings took on Wednesday and Thursday last, when a series of reminiscences and recollections of experiences of the

early days of electrical work were given by leading members of the profession.

The fact that the Institution of Electrical Engineers has a nearer knowledge of the history of the profession for which it stands than has perhaps some of the other engineering institutions, is illustrated by the long list of members who were available to contribute to the account of earlier days. The reason for this is the obvious one that the whole history of the development of electrical engineering lies well within the limits of a present lifetime. The first Atlantic cable was laid only sixty-six years ago. The incandescent lamp was invented only forty-four years ago, and the first telephone exchange dates from about the same time. The amazing present development from these recent beginnings has resulted in the growth of the Institution of Electrical Engineers to a membership of 10,000 and to an authority which it is difficult to assess. The relatively brief period covered by the history of electrical engineering results in the total of 10,000 members, containing many personally familiar with the first steps. This condition clearly cannot continue indefinitely, and the commemoration meetings of this week will bring together and place in permanent form a collection of reminiscences and historical footnotes which will always be of interest and may not infrequently be of service in the developments which will be the heritage of a later generation.

VIBRATIONS OF A SPINNING DISC.

It is common knowledge that there have been many failures of the wheels used for high-speed impulse turbines; with at times very serious consequences. Inquiries subsequent to such accidents have led to the conclusion that in most cases the smash has originated in vibrations of the wheel, due to some one of its many natural periodicities chancing to be in unison with some periodic force. With wheels running with partial admission, it is easy to understand how the wheel vibration may be built up; but the worst failures have been those of low-pressure wheels, working with full admission. It is possible that the requisite periodic force may in some of these cases have arisen from an interruption in the supply of the steam at the casing joint, though many builders take steps to avoid any disturbance here in the uniformity of the steam flow. In a discussion on Mr. Eskel Berg's paper, read before the American Institute of Electrical Engineers in 1919, Mr. Emmet, of the General Electrical Company, described experiments with a rubber disc, the rim of which took the form of a standing wave when the disc was rotated at high speeds. This observation has been confirmed by other observers, but it is by no means clear that it has much bearing on the point at issue. It seems at least possible that were the experiment repeated *in vacuo* that different results would be obtained. Some observations on a German-built turbine, which gave trouble in Australia, showed that the wheels might be set in vibration by sources quite extraneous to the turbine. The wheels in this case were very thin and flexible, rigidity having been sacrificed to considerations of cost. When opened up after the trouble, one of the turbine wheels was observed to vibrate strongly in resonance with some machinery in the station, and on the next day, through some slight alteration in the periodicity of the disturbance, another wheel of the rotor (which, of course, was stationary) was found to have taken up the vibration, whilst that which had oscillated so violently on the preceding day was at rest. This observation appears to indicate the possibility of dangerous vibrations being set up by resonance with some source of vibration outside of the turbine itself. Should this conclusion be confirmed, the problem of securing safety will be very seriously complicated.

However this may be, designers have satisfied themselves that the failures of these large wheels in service have been due to wheel vibration, and that it is important to avoid synchronism between any of the natural periods of vibration of the wheel, and any periodic forces that may act on it. Little has yet been done to investigate the matter mathematically. Kirchoff's solution for disc vibrations apply only to a non-rotating disc of uniform thickness. As actually constructed turbine wheels are many times thicker at the boss than near the rim, but the latter is generally stiffened up to receive the roots of the blade. No doubt it would be possible to find an arithmetical solution of the equations of motion, governing the vibration of even the most complicated of such forms; though it seems certain that it will prove impossible to devise general formulæ for any but the most simple. Even with these it is probable that the mathematical treatment of the problem will prove far too complicated for use in the drawing office. Nevertheless, very considerable interest attaches to a paper on disc vibrations, by Professor H. Lamb, F.R.S., and Mr. R. V. Southwell, which is published in the Proceedings of the Royal Society, Section A, vol. xcix, page 272. The authors confine their attention to the case of a disc of uniform thickness, for which they have succeeded in obtaining solutions, but their most important result seems to be capable of extension to discs of all forms. When a non-rotating disc is deformed the restoring forces are due entirely to the elasticity of the material, but when the disc rotates the centrifugal forces also assist in the work. The authors of the paper in question show that if these two sets of restoring forces be taken to act entirely independently of each other, the periodicity corresponding to each set can be calculated. Thus if p_1 denote the periodicity when the centrifugal forces alone act, and p_2 the frequency of the vibrations under the elastic forces when the disc is stationary, then when both sets of forces act simultaneously the frequency p is, to a first approximation, given by

$$p^2 = p_1^2 + p_2^2.$$

It is further pointed out that the approximate value of p thus obtained is always a little on the small side. It is interesting to note that p_1 (which represents the periodicity when the centrifugal forces are alone in action) is entirely independent of the dimensions of the disc, and for discs of similar form is simply directly proportioned to the angular velocity. On the other hand p_2 the frequency of vibration when the elastic forces are alone in action is with similar discs inversely proportional to the scale. We can thus derive a law of comparison by which the safety of a full-sized wheel could be determined from experiments on a model. This law of comparison takes the form that with equal peripheral speeds the ratio of p_1, to p_2, will be the same for the model as for the wheel. Moreover, if ω_0 denote the angular speed at which the model vibrates, then the wheel will vibrate similarly when run with the same angular velocity. Hence if a model to quarter scale runs steadily at 4,000 r.p.m., the wheel may be relied upon to run steadily at 1,000 r.p.m. By making the model of a different material to the wheel the corresponding speed will be diminished in the ratio of the respective values for the two materials of $\sqrt{\frac{E}{\rho}}$, where E denotes Young's modulus and ρ the specific gravity of the material. Thus if the model above mentioned was made of brass it could be run at about 2,900 r.p.m. instead of at 4,000 r.p.m. The above rule for wheels of different materials is not quite exact since Poisson's ratio is also involved in the problem, but considerable variations in this appear to affect the result but little.

For a thin disc of uniform thickness, the authors of the paper above referred to find for the frequency of vibration of a uniform disc under centrifugal force only the value $p_1^2 = 2{\cdot}35\,\omega^2$. Under elastic forces only the frequency of vibration is given by

$$p_2^2 = 10{\cdot}61\,\frac{E\,h^2}{\rho\,a^4}$$

where h denotes the half thickness of the disc and a its radius. These expressions apply to the case in which there are two nodal diameters. Coefficients for other cases are given in the original paper.

THE PHYSICAL PROPERTIES OF MOTOR FUELS.

Motor fuels like petrol are not of the simple nature of coal which still practically remains the common fuel. A pound of a certain coal will, by its combustion, yield a certain amount of heat, no matter what the thermometer and barometer say. All the same, we are still exerting ourselves to improve our methods of burning coal so as to be able to utilise its available heat energy to the fullest extent. On the other hand motor fuels are liquids or mixtures of liquids which have to be sprayed or vaporised before being ignited, and although our experience in their use has become large, it has extended over a comparatively limited period. In the case of these liquids the proportions of the constituents in the vapours, the ignition point, the explosive range and the heat of combustion will all depend upon the temperature and pressure outside and inside the cylinder and upon other conditions, and such fuels should not be indiscriminately mixed, though they may separately be suitable.

Under these circumstances it is not surprising that in spite of all modern advance, many motor fuel problems are still obscure; and they will always remain complex, although the endless varieties of mixtures proposed do not in reality contain a great variety of constituents. The paper on "The Physical Properties of Motor Fuels," which Dr. W. R. Ormandy and Mr. E. C. Craven read before the Institution of Automobile Engineers last Tuesday, in Birmingham, will thus be welcome to engineers because it correlates a great deal of material (partly new) on the physical characteristics of motor fuels. The engineer will not always find it possible to make the different properties of different constituents harmonise in their mixtures, and very little is yet known as to the influences upon those characteristics of the high pressures within the cylinders, but the problems involved are now being attacked from various points.

In dealing first with heat of combustion, Dr. Ormandy referred chiefly to Mr. Ricardo's researches of last year. Heat of combustion is the most important, but not the decisive factor. Acetylene yields more heat per unit of weight than any petrol, but it is no more suited for internal-combustion engines than fulminate cartridges would be for rifles. All the petrols and also kerosene and paraffins give about 19,000 B.Th.U. per pound; in the naphthenes (cyclohexane of 93 per cent., for example) the figure is only slightly below 19,000, in the aromatics it goes down to about 17,500 (17,800 for xylene, 17,330 for benzene), in the alcohols to considerably lower values, 12,000 for amyl alcohol, 11,000 for ethyl alcohol and 9,000 for methylated spirits. Those figures refer to equal weights. The volumetric relations, however, are different; since the aromatics are denser than petrols (benzene density 0·884 against 0·7 to 0·8 for petrol), and thus their heat values are higher per gallon. But we must bear in mind that the oxygen constitutes really as much a fuel in a combustion process as the combustible. To the coal on the grate we can supply an almost unlimited volume of oxygen. But we are restricted as to space in the internal-combustion motor, and whilst almost all hydrocarbons and alcohols, mixed with the theoretically required amounts of oxygen, give fairly the same heat per volume of fuel, the volumes of the gases produced vary. In the case of hydrogen and carbon monoxide the resulting gas vapour volume is smaller than the original gas volume by about 15 per cent.; in the paraffins and alcohols it is greater by 6 per cent., in the aromatics smaller by 2 per cent. only.

But we have first to convert our liquid fuel into vapour, and in a cold winter the spirit might actually freeze. Benzene solidifies already at + 5 deg. C. According to the British standard the freezing-point of a benzol should not lie above — 14 deg. C. The freezing point of benzene is lowered by mixing it with other motor spirits, strongly by toluene, less so by kerosene, and least by alcohols. In order to keep above that standard freezing-point, 30 per cent. of toluene would have to be added to the benzene, if the commercial toluene did not contain paraffins and sulphur compounds which have the same effect. At present, however, a benzol of a freezing-point of — 8 deg. C. is on the market.

The next point to be considered is the likelihood of a separation of the mixture into its constituents. The more common hydrocarbons are miscible in all

proportions with one another, but not with alcohols. On behalf of the Distillers Company, Dr. Ormandy and Mr. Craven have studied the mutual solubilities between + 30 deg. and — 30 deg. C. Benzene is highly soluble in commercial alcohol (95 per cent.), but at 2·5 deg. C. already (only 2·7 deg. below the freezing point of benzene) a solid benzene phase falls out. That does not occur with toluene above — 30 deg. C.; but xylene is much less soluble. Edeleanu extract of Borneo kerosene is apt to separate, and small percentages of alcohol are not soluble in this extract either. The latter point is not unimportant. It is sometimes desirable to dissolve a little (5 per cent.) of alcohol in a petrol in order to reduce the tendency to pinking; but some petrols will not dissolve small percentages of alcohol (whilst the alcohol will dissolve small percentages of petrol), unless the alcohol be very strong (above 95 per cent.) and especially dehydrated; the addition of amyl alcohol to the mixture is one of the expedients advisable in such cases.

As regards the distillation range the engineer wants to know the temperatures when distillation commences and when it finishes, and also the half-way distillation point. Comparing a Pratt No. 1 and a Shell spirit, Dr. Ormandy found that the former admitted of starting the motor at a lower temperature than the latter, but there was little difference as to the temperatures at which half the spirit had passed over in Engler distillation, which is regarded as a guide to the behaviour of the spirit in the engine. Further, the Shell spirit had practically all (95 per cent.) distilled at 169 deg. C. and the Pratt at 188 deg. C.; the latter, therefore, contained probably more kerosene-constituents, difficult to volatilise and more likely to ooze through into the crank-case and to reduce the viscosity of the lubricant. In this respect, Dr. Ormandy remarked, British motor spirits are so far preferable to some American gasolines. The next point to be discussed in this connection, the carburation, depends upon the latent heat of evaporation. The heat absorbed in the evaporation of the fuel has to be replenished lest the fuel-air mixture be cooled. The heat of evaporation per pound of fuel is about 135 B.Th.U. for petrols, 164 B.Th.U. for benzol, and 400 B.Th.U. for alcohols. The cycle of operations is too rapid to impart that heat to the in-rushing air, and the vapours are generally brought in contact with a "hot spot." A high heat of evaporation is advantageous because, if the fuel can be brought into the cylinder in a fine state of subdivision, its evaporation reduces the temperature of the mixture at the expense of heat taken from the cylinder walls or from the heat of compression, with an increase in the weight of the charge that can be drawn into the cylinder.

The flash-point and the easy starting are mainly determined by the amount of readily-volatile vapour, but all the fuels of the same flash-point need not be equally easy in starting or equally efficient in running. The recent work of Dr. Ormandy and Mr. Craven on flash-point temperatures was noticed on page 81 of our issue of January 20. To propagate the flame the molecules must be brought within close reach of one another, and in the case of methyl alcohol that requires 2·3 times the pressure necessary for dealing with hydrocarbons. With increasing molecular weight that factor diminishes, to 1·4 for butyl alcohol, and to 1·5 for ether. Inert substances like CO_2 raise the flash-point, oxygen lowers it considerably. The explosion ranges of the hydrocarbons lie between 1½ per cent. and 4½ per cent. by volume. Those of the alcohols are much larger, especially in the case of alcohols of low molecular weight: methyl alcohol 3·6 per cent. to 21 per cent., ethyl alcohol 3·4 per cent. to 10·6 per cent. But we know very little about flash-points and explosive ranges at higher initial pressures.

That remark applies unfortunately also to the spontaneous ignition temperatures, on which we have dwelt on various occasions recently in connection with the work of Harold Moore and others. The values obtained by various methods and experimenters are not in accord, and their interrelation with the other properties, even the "toluene numbers," of the motor fuels are not understood. The toluene number of Ricardo indicates the tendency to "pinking," i.e., detonating at a certain compression. Toluene and aromatics generally have high toluene numbers, higher than the naphthenes and the true paraffins. The most recent experiments of Ricardo show that alcohols can bear still higher compression than toluene without pre-igniting. These features are important in view of the modern preference, due to economical considerations, for cylinders of small dimensions. High compression ratios are adopted in these cylinders, and "super-efficient" engines, unless fed with special fuels, are likely to become "super-nuisances," as Dr. Ormandy put it.

We have mentioned already that additions of alcohol to benzol reduce the tendency to pinking. The experience of the London General Omnibus Company with such mixtures seems, however, to be more unfavourable as to corrosion than Continental experience had been. The company found that even the iron tanks of benzene-alcohol mixtures corroded unless made of terne plates, sheet iron coated with an alloy of lead and a little tin. Dr. Ormandy added that small amounts of alkali will prevent this corrosion, and that pyridine, the official denaturant of alcohol, is sufficiently alkaline for this purpose; that would redeem pyridine, which is mostly a very undesirable impurity, to a certain extent. The corrosion due to a partial oxidation of alcohol to acetic acid may become serious, *e.g.*, when an iron tank is connected by a copper pipe to an aluminium carburrettor chamber containing a brass float with soldered joints; Dr. Ormandy recommends a solder of two parts of tin to one of lead to minimise this electrolytic corrosion. The small amount of sulphur in modern petrols has no corrosive effects; the surface film of sulphide forming in the cylinders may act as a protective coating in the absence of water.

The only other property, on which Dr. Ormandy commented, the viscosity of the fuels, concerns mainly jet carburettors. The various petrols differ little in viscosity; if they have a viscosity of 5, however, the relative viscosity of benzol is 6, and that of the alcohols is 11. The various temperature coefficients of the viscosity differ far more, however, and a jet carburettor set for 15 deg. C. will not give the correct amount of fuel in unaltered proportions at 30 deg. C. There are naturally other properties to be considered, specific heat and dissociation among them, and a great deal more research work will have to be done before we can obtain a clear insight into the inter-relation of the physical and chemical properties of fuel mixtures. Much of this work should really be conducted in internal-combustion motors, and engineers will therefore have to largely depend upon their own experiments for obtaining the information required.

NOTES.

Asbestos Yarn-Coated Electrodes.

An application was recently made to the High Court in connection with the patent for electrodes for soldering and depositing metals by the electric arc wound with asbestos yarn subsequently coated, which is out of the run of usual court procedure, although occasionally such an application is made. A petition had been presented for revocation of the patent and during the proceedings the court was moved to give leave for the amendment of the specification. The amendment allowed by the learned judge involved the cancellation of two claims and deletion of certain parts of the specification in such a manner that the amended document did not make the invention substantially larger than or substantially different from the original invention claimed. The matter described in the specification, namely, that of Letters Patent No. 142,934, is of interest because it gives some historical references to the state of this art which is at present well to the front. Thus it is shown that methods and processes have been known for covering the wire forming the electrodes for arc welding with slag-forming material, the wire for example being first dipped into water glass and the slag subsequently applied, aluminium or other body being added if desired. Again, a chemical compound of the nature of cement is indicated, this constituting a slag-forming material extruded upon the wire. Later in the art an improvement is described in which the wire is first wound in open spirals of asbestos yarn previously passed through a bath of silicate of soda, the spirals guiding the wire centrally through the extruding apparatus and forming a key for the compound, but this particular embodiment, it is suggested, has the disadvantage that the special compound gradually sets in the extruding machine. According to the amended claims of the patent in question in the action the electrodes are wound with asbestos yarn in open spirals coated with a silicious compound and a fluid slag-forming mixture containing lime is subsequently added with or without a suitable proportion of powdered aluminium.

Electrical Development.

At the annual luncheon of the British Electrical Development Association, which was held on Wednesday at the Hotel Cecil, Mr. Ll. B. Atkinson, speaking to the toast "Electrical Progress," remarked that it was the object of the association to pass on to the public the knowledge which they, inside the industry, had of electricity. The high price of fuel drove large consumers to the supply companies as their power was economically produced. Domestic difficulties had increased the number of small users, and electricity was largely used to-day in the homes as well as in the larger services such as railways, &c. There was capital ready for use in the electrical industries to-day, if only there was greater certainty with regard to the future. We had got away to some extent from the parochial view, and more rational grouping was probable under the Electricity Commissioners, but there was still hesitation which could only be removed by a knowledge that no legislation was likely to be introduced to further hamper development. The toast was replied to by Mr. Arthur Neal, M.P., of the Ministry of Transport, who stated that the only legislation to be introduced in the near future was a Bill which would be brought before the House of Lords shortly with the object of clothing the authorities involved in the new London scheme, with financial powers, which he thought all would welcome. The 1919 Act had planned out the country into suitable divisions, and had got away also from central control. The worst problem under the new scheme was that of London, and that was virtually solved. With regard to the electrification of railways the difficulties between the companies were, he thought, in a fair way to being surmounted. In proposing the "Electrical Industry," Mr. E. C. Ransome, O.B.E., president of the Electrical Development Association, said what was now wanted was confidence and some relief from the crushing taxation of the present day, the latter being a necessary preliminary to any revival of business. He looked for electrification of railways in this country on a large scale before long, while on the roads the electric vehicle was more and more asserting itself and station engineers would be well advised to cater for it.

The Institution of Electrical Engineers.

The annual dinner of the Institution of Electrical Engineers, coinciding as it did this year with the celebration of the fiftieth anniversary of the founding of the Institution, was a function of somewhat special interest. It took place on Tuesday evening last at the Hotel Cecil, approximately 500 members and guests being present, including a large number of distinguished men. The president, Mr. J. S. Highfield, was unfortunately precluded by illness from attending, the chair being taken in his absence by Dr. W. H. Eccles, F.R.S., vice-president. The Duke of York, who, it was hoped, would have been present as the principal guest of the Institution, sent a message regretting his inability to attend, and expressing his best wishes both for the success of the evening and for the future of the Institution. Friendly messages were also received from the principal kindred organisations in America, France, Italy and Holland, and from Mr. Thomas A. Edison. The health of the Institution was proposed by the Right Hon. F. G. Kellaway, P.C., M.P., the Postmaster-General, who drew attention to the close association of electrical engineers with the Post Office during the last half century. When the Institution was founded in 1871, it numbered about 100 members, and the most important branch of electricity was then telegraphy. Now there

were over 10,000 members, and the industrial applications of electricity were beyond the wildest conjectures of the pioneers. It was not till 1879 that the first public telephone exchange was opened. Twenty-five years ago wireless signals were transmitted experimentally by Marconi, under the auspices of the Post Office, for a few hundred yards, but only that morning he had been informed that the Post Office wireless station at Leafield could keep in communication with vessels sailing round the Australian coasts, except under very bad atmospheric conditions. British scientific men, including Faraday, Kelvin, Lodge, Wheatstone, Bell, &c., had played a preponderant part in the developments which had taken place. The chairman, in responding, reminded the members that this was the first dinner since they had possessed a Charter, and the King had consented to become their patron. The Institution had now a membership exceeding that of any other Institution in the country. Mr. Ll. B. Atkinson, past-president, proposed the health of the guests, the toast being responded to by Air-Marshall Sir H. M. Trenchard, Bart., K.C.B., and Mr. Justice Sargant.

The Internal Decoration of Ocean Liners.

It is no reflection upon the important work of the naval architect and marine engineer to say that something further is required to produce the comfortable and elegant floating home which the travelling public now demands in the modern ocean liner; obviously the combined efforts of many specialists are required. Certainly some of the super-luxurious equipment, such for instance as swimming baths, has generally been omitted from post-war liners, but no reduction in the standard of elegance of the public rooms or of the comfort and convenience of the accommodation is noticeable in recently completed vessels of the class referred to. If anything, in fact, the standard has been raised, as evidence of which we may refer our readers to the photographs of the interiors of the s.s. Conte Rosso reproduced in our last issue. The internal decoration of ocean liners formed the subject of a paper read before the Royal Institute of British Architects by Mr. Arthur J. Davis, F.R.I.B.A., on Monday last. In this paper the author traced the development of decorative art as applied to passenger vessels from the time of the early Cunarder Britannia, the saloon of which was described by Charles Dickens as "a gigantic hearse with windows in the side," to the modern Cunard and White Star vessels, most of which have been illustrated in our columns at various times. The size and importance of the public rooms of a liner, has become so great, Mr. Davis remarked, that the expert knowledge of the architect is necessary to deal with their arrangement and decoration, and his services are also employed in connection with the planning of the accommodation and the internal arrangements generally. The author, however, made it quite clear that the architect must work out the interior scheme in collaboration with the ship designer and must necessarily defer to the latter in all matters affecting, or affected by, the construction of the ship itself. He also pointed out that methods of design applicable to buildings on land could not be employed at sea without modification, and, in this connection, referred particularly to the effects of sheer and camber. A warning against the employment of heavy and incongruous ornamentation was also given, the author remarking that this was particularly out of place in ship decoration since the rooms of a liner always appeared to be smaller than those of equal dimensions on land; he attributed this effect to the absence of heavy constructional piers, deep window and door recesses, &c. The author deprecated the exaggerated use of skylights and glass domes, and stated that with the exception of vestibules, galleries and staircases, all reception rooms should be lighted laterally wherever possible. After some useful remarks as to the materials available, styles of decoration, arrangement of staircases and other architectural features, the author concluded a suggestive and informing lecture with the sound advice that the architect must in all cases carefully consider the special conditions of service under which the vessel he is dealing with is to be employed.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An extraordinary general meeting of the Institution of Mechanical Engineers was held on Friday last at Storey's Gate, St. James's Park, S.W. 1, for the purpose of confirming the alterations in the Articles proposed and discussed at the meeting of the 20th ult. The president, Captain H. Riall Sankey, C.B., C.B.E., was in the chair. On being put to the meeting the alterations as proposed at the previous meeting were carried.

After a reference to the late Sir George Carter, and his connection with the Institution, the meeting resolved itself into the annual general meeting, and after preliminary business a number of alterations to the by-laws were considered. These for the most part had to do with changes which became necessary as a result of the confirmed alterations in the Articles. They were duly passed after some discussion, with two small amendments put forward at the meeting.

Annual Report.

The annual report of the council was then considered. The following is a summary:—

The seventy-fifth annual report showed a net increase on the roll of 491, the total names thereon amounting to 7,994. There were 810 additions during the year, including 2 honorary members, 151 members (including 80 transferred from the associate member class) and 327 associate members (including 3 reinstated). The total deductions were 319, including 103 members deceased or resigned, &c., and 145 associate members, including the transfers to the class of members. The most numerous additions in the year were 324 new associate members, and 323 new graduates elected. The losses to the Institution by death included Sir Samuel Davidson, Sir Douglas Fox, Mr. E. Windsor Richards, Sir T. Salter Pyne, Sir Thomas Wrightson, Mr. Walter Pitt, and Mr. William Daniel. The accounts showed a balance of revenue over expenditure of 2,049*l.*, the revenue amounting to 29,587*l.* and the expenditure to 27,537*l.* The Research Committees had continued at work. The Alloys Research Committee had completed its work on Aluminium and its report had been presented. Cutting tools research work had been carried out and a report would be presented this session. A committee is at work on hardness tests and has dealt with ball and cone tests, and scratch and indentation tests for very hard steels. The Steam Nozzles Research Committee had carried out experimental work in Manchester, and research on wire ropes was being conducted at Woolwich Polytechnic. The Thomas Hawksley gold medal for 1922 had been awarded to Professor E. G. Coker for the best paper published during the year, and premiums of 5*l.* each had been awarded to Mr. K. C. Chakko and Mr. M. S. Ahmed. A sum of 15*l.* from the T. Bernard Hall Prize Fund had been awarded to Mr. A. A. Jude. The Sir Robert Hadfield prize had been awarded to Messrs. R. L. Smith and G. E. Sandland (20*l.* in each case). In connection with the associate membership examinations a prize of 5*l.* had been awarded to Mr. W. H. Lewis, and 3*l.* each to Messrs. W. C. Neate and R. C. Bond in connection with graduate examinations. Prizes of 6*l.* and 4*l.* respectively were awarded to Mr. A. G. Hopking and Mr. E. T. Vincent for papers read before the Graduates' Section. The scheme of national certificates and diplomas had been adopted at a number of technical schools and colleges. A successful summer meeting had been held in London, in conjunction with which there had been an exhibition. The eighth Thomas Hawksley Lecture had been delivered in November by Dr. H. S. Hele-Shaw. Local branch centres had been established in the Midlands, North-West, Yorkshire and South Wales. Informal meetings had been held in London. The Institution had assisted the authorities in various ways in connection with the supply of technical officers and men for His Majesty's Army and Air Force. The Institution had moved in the direction of closer co-operation with other institutions, and a conference was to be called to consider possible action.

After the President had drawn attention to one or two points in the report, Sir J. Dewrance, K.B.E., as chairman of the Finance Committee, made a few comments on alterations in the form of accounts. Some discussion ensued, after which the report and accounts were adopted. The next business was the presentation of the prizes awarded as mentioned in the report given, following which the result of the ballot for the election of officers was announced.

Election of Officers.

The following have been elected for the ensuing year: President, Dr. H. S. Hele-Shaw. Vice-presidents, Sir John Dewrance, Sir Henry Fowler, Sir Gerard A. Muntz, Mr. W. H. Patchell and Sir Vincent L. Raven. Members of Council, Lieutenant-Colonel E. Kitson Clark, Mr. E. W. Petter, Mr. F. H. Livens, Dr. F. W. Lanchester, Mr. L. A. Legros and Mr. D. E. Roberts.

The retiring president, Captain H. Riall Sankey then vacated the chair in favour of the new president, Dr. H. S. Hele-Shaw.

Sir John Dewrance next proposed a vote of thanks to the retiring president, Captain H. Riall Sankey, remarking that he was speaking on behalf of Dr. W. H. Maw, who was unfortunately unable to remain for the whole meeting. The retiring president had not only upheld but increased the dignity of the Institution with the engineering profession in this country and throughout the world. Sir Gerard A. Muntz, in supporting the vote, said that he had not known, among the various presidents he had served under, one who had done more for the Institution than Captain Sankey, who had worked the council so hard that his sympathy went out to the president now entering upon his term of office.

The President then put the vote to the meeting, observing that Captain Sankey had combined with his capacity for hard work the best traditions of the profession of the Royal Engineers to which he belonged. The vote was carried by acclamation.

Captain Sankey, thanking the meeting, said that he had always endeavoured, since he joined the council, to do his utmost for the Institution. The work he had done, in that connection, was the most pleasant in his experience. If he had helped forward any improvements, it was because, when he became president, these improvements were in course of development; some were his own ideas, but many others were not.

Electric Welding.

The paper set down for reading and discussion was one entitled "Electric Welding Applied to Steel Construction, with Special Reference to Ships," by Mr. A. T. Wall, of Liverpool. We print this paper in full on page 241 of the current issue.

The President, in proposing a vote of thanks to the author, said that the paper was valuable and opportune. The Fullagar had, as the author stated, carried cargoes of steel plates and similar material in very heavy seas, without showing any signs of failure at the welded joints, and had actually received an indent without starting the welding.

Professor E. G. Coker, F.R.S., opened the discussion. He said the feature which he proposed to discuss related to the addition of doubling pieces welded on at the corners of rectangular openings in a ship's side to strengthen the plate at these points. These were undoubtedly necessary owing to the increased stress caused by the discontinuity, and it would possibly be of interest to describe the distribution found in some experiments on discontinuities of this kind. If a rectangular hole with rounded corners was cut in a loaded tension member an extremely variable stress was produced at the inner contour, and in somewhat less degree at the outer contours, depending on the dimensions of the hole in relation to the width of the member. In a particular case examined by Mr. A. L. Kimball and himself a centrally-placed square hole of 2 in. side with corners having a radius of $\frac{1}{2}$ in., was cut in a tension member 5 in. wide, and subjected to a load which gave a mean average stress across the central minimum section of 840 lb. per square inch, and it was then found that the stress across this section varied from 1,270 lb. per square inch at the inner contour and a minimum of 540 lb. per square inch at the outer contour, and the variation was not a linear one, although the departure from linearity was not very marked. Around the inner contour the maximum stress was very much greater, and as shown in Fig. 1 a maximum tension of 1,730 lb. per square inch was reached at a point of the contour near the commencement of the rounded corner; this indicated how necessary it was to strengthen the plate at these points after the manner indicated in the paper. Along the edges perpendicular to the line of load the pull on the member caused a compression of the material of 470 lb. per square inch, and this great variation at the corners emphasises still further the need of strengthening pieces.

It was of interest also to remark that the effect of the discontinuity was to induce maximum stresses at points of the outer contours which were well beyond the discontinuity, as shown in Fig. 1. This case was not quite the same as the one described by the author, since in a ship's side the stresses were

mainly due to bending, but as the sizes of such openings were small, in comparison with the dimensions of the ship's side, they gave a fairly accurate idea of the stress conditions to be met.

During the last few days, and since the paper had come into his hands, he had been so interested in this feature that he had asked two of his research students, Messrs. Anderson and Fukuhara, to examine the distribution caused by a square hole in a beam, and they had made some preliminary measurements of such a case which he would describe very briefly, although he wished to point out that the natural limitations of such laboratory work did not allow of an imitation of a beam, say 60 ft. deep and many hundred feet long, with a rectangular hole of just sufficient size to walk through.

In this case the beam (shown in Fig. 2) was 1·115 in. deep, with a nearly centrally-placed hole ½ in. square, with corners of $\frac{1}{16}$ in. radius, supported on knife-edges and loaded at the overhanging ends to give uniform bending moment at the central part

Fig. 1.

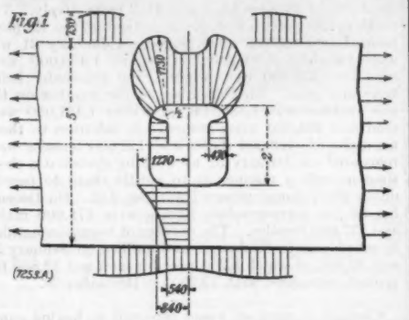
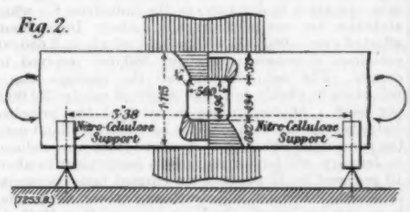


Fig. 2.



well away from the supports. This condition was not obtained perfectly, however, as the effect of the supports seemed to prevent the free play of stress and strain at the under side of the beam, and possibly affected the distribution somewhat, but time did not permit a trial of roller supports.

As a consequence the distribution across the central section probably showed a more non-linear stress distribution than would otherwise be the case, and the lower side was probably very much influenced by this resistance at the supports, for at the inner contour the stress was found to be very uniform along the sides parallel to the outer edges of the beam with only a slight tendency to increase as the corner was approached, and rapidly falling to zero after passing round the corner. Little or no stress was observable along the vertical sides, and, as in the previous case, the maximum stresses at the outer edges were found well away from the central section, but were only a few per cent. larger than the minimum values of the central cross-section. As would be seen this latter case was more analogous to a hatchway opening in a ship's deck subject to bending in a horizontal plane, but as the information it gave supplemented in some measure the earlier case he thought it would be of interest as a contribution to the discussion.

Mr. S. V. Goodall, of the Naval Construction Department, agreed with the author as to the disadvantages of riveting, but the latter had omitted reference to two other disadvantages. It was desirable in warship construction to have an "intelligent" connection; one that would hold up to the work as long as possible, but one which, when it failed, would, in certain instances, give way absolutely. For instance, he would refer to the connection of a stringer to a watertight bulkhead. He had seen cases of torpedoed ships in which the watertightness of the bulkhead was ruined, because, owing to the pull on the damaged stringer, the rivets had been pulled through the bulkhead. Another desideratum in warships was a means of connecting plates of considerable thickness. In H.M.S. Hood the plates had a combined thickness of about 2¼ in., and a joint was desired which would give adequate strength for that thickness. Before the Washington Conference greater thicknesses were in contemplation in which it was hoped that electric welding would be of assistance, because with greater thicknesses it was impossible, owing to practical limitations in regard to length and diameter of rivets, to obtain the amount of strength required. He joined issue, however, with the author in his rather strong advocacy of electric welding for all purposes, and, reading between the lines of the paper, the author did not appear to believe in it himself, quite to the extent suggested at first sight. He had referred to the advantage of doing the work in the shop, the assumption being that in bad weather electric welding would have to be stopped. He had also mentioned that the Fullagar had received a minor indent; it was, of course, necessary to "cater" for major indents in the case of warships.

Experiments had shown that against the shock produced by the impact of a shell, electric welding was not so good as riveting. With regard to the tendency there was said to be for plates to creep and shift during the welding process, he thought the author might develop that point; in welding ships' plates together, there would certainly be difficulty due to the effect of heat. Referring to Fig. 9 in the paper, showing angle-bars welded at the butts, he would be glad if Mr. Wall would say whether he found that welding between the joints caused the rivets to work badly. It might interest the meeting to know that the comfort of H.R.H. the Prince of Wales was, to a certain degree, dependent upon electric welding. When H.M.S. Renown was fitted out for him, time was too short to permit of putting on a wood deck in the usual way, and studs were welded to the plating and the planks bolted down. The ship's guns had been fired, but he had not had any adverse reports. The Admiralty had adopted welding, in an experimental way, and it had been proposed to extend the use of the process in the battle cruisers now to be scrapped. He mentioned that fact as it made it painfully obvious that the scrapping of these ships meant the slowing-down of progress in applied science.

Mr. W. H. Thorpe alluded to the author's remarks as to the considerable increment of stress at the sides of a rivet hole when a tension piece was under a pull. The author's suggestion was that a piece with a hole offered a less resistance; as a matter of fact, however, if a piece with a drilled hole in it were submitted to tension and broken, the ultimate stress of the piece, reckoned upon the net section, was slightly greater per square inch than the ultimate stress upon the unpierced piece. It would be foolish to deny the increase of stress, but he suggested that there was also an increase of resistance. While laboratory experiments were of the greatest value it was quite possible to misinterpret them, and, instructive as they might be, they must ultimately submit to experience gained by the long use of materials in actual structures. The test—so to call it—that long experience developed, gave results inclusive of all the variables, and included both the known and the unknown. The author had referred to the rigidity of the butt weld, and it was suggested that as the break commonly occurred away from the weld the circumstance afforded an indication of the advantage of the electric weld. He (Mr. Thorpe) denied this. No electric weld could be considered perfect—perfection was unattainable perhaps—until the piece broke, perhaps at the weld and perhaps elsewhere, to afford evidence of equal ductility and the same properties throughout. He had been shown a bar, originally a 2-in. bar, built up by electric welding, which was submitted to him as a piece of excellent work; it was bent and showed no break. He found that the original metal was on the outside, and asked to see a piece in which the bend was made the other way. When he was shown such a piece, he saw what he rather expected—cracks in the weld metal.

Captain Sankey referred to Fig. 5 of the paper, in relation to which he had hoped that Professor Coker would have enlarged a little on the results of experiments in the application of the doubling pieces. Perhaps the professor could carry out experiments in this connection, letting the Institution have the results for use in the "Proceedings."

Professor Coker said he would endeavour to do this if the time permitted.

Mr. Richard Williamson asked the author if he could give information with regard to the action of sea water on electric welding, an important point to shipowners.

Mr. D. B. Morison agreed as to cost being greater with electric welding than in the case of riveting. His company had developed electric welding, but were handicapped by trade unionism. Electric welding offered immense possibilities, but the work required good men, and men who were sympathetic, and not dominated by their unions. Constructive engineers had before them a more difficult time than was usually imagined, and it would only be possible for them to hold their own with the aid of electric welding and the various other scientific developments offered. The sympathetic assistance of the operator was essential.

Mr. A. T. Wall, in reply to the discussion, said with regard to Professor Coker's experiment, that his own case had been a more practical question—the case of a ship considered as a beam of anything from 70 ft. to 90 ft. in depth with, near the top edge, a hole some 5 ft. or 6 ft. deep. That hole was not in the middle of the beam, and he considered that he was justified in regarding the conditions as those of practically a pure tension member, the distance from the lower edge of the hole to the top edge was so small compared with the mean distance from the neutral axis. It was a matter of experience that the corners of the windows and doors in the superstructure of ships did break away, whatever the breaking stress of a plain tension member with a hole in it was compared with that stress if not punctured. With regard to Mr. Goodall's remarks, he would say that to-day electric welding was somewhat "parochial," and should be more extensively and generally considered. All kinds of extraordinary things were going on in welding, and he doubted whether it was having a fair trial. His principal object in bringing the paper before the Institution was to assist in placing it on a proper basis. The question was not welding *versus* riveting, but the best line of progress; not of displacing rivets because they were rivets, or adapting welding because it was welding. He sympathised with Mr. Morison's complaint as to labour; he had had labour troubles on the Fullagar. In answer to Mr. Williamson, the action of sea water on welds had been very carefully tested in the laboratory and elsewhere on a larger scale; and it was found that there was virtually nothing in it. After riveting a mild steel plate and a hot rivet had been hammered up, the plate was damaged to a certain extent, and the difference in electromotive force—to-day considered the chief element in setting up corrosion—would be greater as between the unhammered plate and the hammered plate, than as between the mild steel plate and the electric weld. There was no reason for fear on that score.

The President then announced that the paper was to be read and further discussed at the Memorial Hall, Manchester, yesterday, the 23rd inst. He also stated that the graduates' annual lecture would be delivered by Sir Henry Fowler, K.B.E., on Monday, February 27, at 7 p.m., the subject being "Metallurgy in Relation to Mechanical Engineering;" the meeting would be also open to members. An informal meeting would be held on Friday, March 3, at 7 p.m., when the subject of "Spiral Bevel *versus* Straight-Tooth Bevel" would be introduced by Mr. A. P. Bale.

SUMMER HOLIDAY COURSE, NANCY UNIVERSITY.—Our attention is called to the summer holiday course of the Faculty of Science at the University of Nancy (France), which is open from July 18 to August 22. Particulars are obtainable from the hon. secretary, British Bureau, Office National des Universités, Engineering Department, 45, Great Marlborough-street, W. 1.

INDUSTRIAL NOTES.

The disaccord which exists between the men, their Executive Council and the Engineering and National Employers' Federation, in the matter of freedom of management and overtime, the ballot concerning which we recorded on page 136 *ante*, now threatens to end in a lock-out in the engineering industry throughout the country. The Employers' Federation issued last Wednesday the following statement: "As was generally expected, the recent ballot vote of the Amalgamated Engineering Union challenging the right of the employers to exercise managerial functions has had grave effects. The Federation intimated to the Executive Council of the Amalgamated Engineering Union that in view of the situation created by the ballot, federated firms will not give employment to members of the society after Saturday, March 11, and that formal notices to that effect will be posted at the various works this week end."

Although we do not always agree with every statement made by Mr. W. A. Appleton, the general secretary of the General Federation of Trade Unions, we are fully convinced that if every British labour leader had his clear and discerning way of confronting many of the problems which now face this country's industries matters would soon improve. Matters indeed would probably never even have reached their present unfortunate state. Other labour leaders remind us in some respects of present-day Russian officials who state: "Now that the famine in the Volga provinces has reached its most acute stage, it is time that the Governments of Western Europe should begin to realise that the decision of life or death for millions of the peasant population *lies with them*." The italics are ours. Unemployment in this country can for a large part be traced back to the coal strike and also to the ship joiners' strike, and unemployment having intensified since, Government is approached with the claim that a solution of the difficulty "lies with it." Mr. Appleton deals with the situation in the following words, in the eighty-ninth quarterly report of the General Federation, which came to hand this week: He says: "Many of our troubles arise from our disinclination to face the facts with which history and experience surround us. It is this disinclination which leads us to confuse the desirable with the attainable . . . to involve ourselves in situations which, while appearing to offer immediate advantage, actually precipitate disadvantage . . . To examine the facts which govern trade and industrial existence with the same care and with the same regard for truth as the scientist displays when he analyses the elements, requires a state of mentality which has not yet been generally developed."

In the same report, Mr. Appleton complains that "the necessity in this country for inserting in contracts strike clauses safeguarding the manufacturer or the contractor against losses arising out of sudden strikes imposes a very serious handicap as against countries where such clauses are unnecessary. They indicate," he adds, "a liability that may not always mature, but which always threatens and frightens prospective purchasers . . . and before recovery can take place these uncertainties must be reduced." We quite agree with him in this; the handicap he refers to will only disappear when labour decides "to play the game."

There is more in the report which we should like to quote if space permitted, but we shall limit ourselves to the following paragraphs. Mr. Appleton finds that "there must be a new conception of the value of skill, which is the workman's most valuable and portable property. Recent industrial developments have tended to discredit skill, but without it the people of Britain cannot earn enough to maintain themselves. Other countries are just as able to perform rough and ready work as we are . . ." We are sure no British works' owner disparages any of his skilled men, for whom there is still full scope notwithstanding every industrial development. The tendency, very prevalent, unfortunately, of ascribing skill to the British workman exclusively, whilst "rough and ready work" is ascribed to the workmen of other countries, is based on absolutely false grounds. Foreign workmen are quite as skilful as British workmen in every way, and in every branch of industry; they can turn out work which is quite as perfect as work done by British workmen and frequently with a degree of finish—useful finish we mean—which the latter would find difficult to imitate. The saloon and cabin work of the Conte Rosso, illustrated in our last week's issue, designed and carried out by Italians, affords one case in point for one branch of industry, among many others which could be cited.

On January 31, the percentage of unemployed in the shipbuilding and ship-repairing trades throughout the country was 35·2. The percentage of persons claiming unemployment benefit in respect of systematic short-time working was 1·1. Employment with ship joiners on the Tyne was reported as being fair; on the Wear it was bad, and worse than in December. On the Tees, firms continued to reduce their staffs. At the majority of the East and South Coast ports, and at the Bristol Channel ports, employment remained slack. There was a slight improvement in repair work on the Mersey, but at Barrow a further decline was experienced. On the Clyde, employment continued bad on the whole and was worse than in December, though with joiners it was reported fair. The shipbuilding and repairing trades also remained bad at Dundee, Aberdeen and Belfast.

Dealing with the present crisis in the shipbuilding and ship-repairing trades, and refuting Mr. Hill's statements in the report for this month of the United Society of Boilermakers and Iron and Steel Shipbuilders, a contributor to the *Newcastle Daily Chronicle* states that there is no question of an employers' attack on wages; what there is to-day is a consumers' strike against high prices, and employers have no more to do with this than the workmen have. The journal adds that at Continental ship-repairing yards there has been extreme activity for several years. Not one dry dock at Antwerp had been unoccupied a day since the armistice. Rotterdam, Hamburg and other ports had been in full activity all the time. The Continental men worked three shifts per day and overtime when required, and double shifts was a common practice, whilst the British unions worked only one shift per day and limited overtime to 6 hours per week. Ship-repairing firms abroad guaranteed shipowners and agents that the labour would proceed at the rate of at least 20 hours per day on repair jobs.

The result of the ballot on the owners' proposals regarding the withdrawal of the 26*s.* 6*d.* war bonus will soon be known. It is reported that the leaders of the trade unions concerned have been strongly advocating the rejection of the measure. If it is rejected, the British yards will continue to stand still, work will continue to flow to foreign yards, another of our staple trades will get into a state of absolute chaos, and Government will be asked to find a way out of the difficulty and to supply doles in the meantime. As our readers are aware, this crisis in the shipbuilding trades is quite apart from that in the engineering trades, to which reference is made above.

On the occasion of the Engineering Conference of the Institution of Civil Engineers, reported in our last volume (Engineering, vol. cxii, page 140), several speakers, among them Mr. Harbord, dealt in Section IV with the difficulties which surrounded the British zinc industry. It is now reported that the British Lead and Zinc Mine Owners' Association issued last Saturday a statement showing that the effect of the policy pursued by Government in regard to the importing of Australian zinc concentrates was that all outlets for home ore were being definitely closed, and that if Government continued to resist the claim for equal treatment with the Australian mines, the industry must be closed down until June 30, 1930, there being no prospect of an economic basis for production until then. It is alleged that this country is involved in an undertaking to buy the whole of the Australian production of concentrates up to 250,000 tons per annum, at a fixed price, until that date. It is also asserted that the ore will have to be sold below cost price, and that an arrangement has been made with the zinc smelters in this country to supply them with Australian concentrates at 3*l.* 15*s.* per ton, whilst the English mines can only obtain 35*s.* to 40*s.* per ton at the mine for their material. The association states that the only equitable course is to include the home production in the Government's purchase scheme. It is further reported that all the British zinc and lead ore mines are at present idle, and it is feared that some of them have been lost permanently.

Speaking at a special meeting of the Leeds and District branch of the Federation of British Industries last Tuesday, Colonel O. C. Armstrong, the president of the federation, stated that after bringing values on to a common basis he found the British export trade in 1921 to have been rather less than half of what it was in 1913, whereas taxation was approximately five times as great. After referring to the Geddes reports, Colonel Armstrong stated that it seemed essential to him to accept that there was a varying, but annually determinable amount of tax which could be paid by industry, and if that amount were insufficient for Budget requirements, then funds must be found from other sources, primarily from further stringent economies. Colonel Armstrong added that the information at the disposal of the Federation gave but small hope of a general revival in our home and export trade in the near future; all indications and the weight of opinion justified the belief that we may have to wait a year, or possibly longer, before the trade barometer again stood at "set fair." Our record in the foregoing of the difficulties in the engineering and shipbuilding trades add weight to Colonel Armstrong's opinions.

The Ministry of Labour report that unemployment during January continued bad, showing little change from the very low level of recent months. In practically all the principal industries large numbers of workpeople were unemployed and short-time working was general. In the coal-mining, tin plate and sheet steel trades, the improvement previously reported was maintained on the whole, and employment was fair, but there was a further decline in the iron mining, building, brick-making and cement industries, and in several branches of the metal trades. The percentage unemployed among members of trade unions from which returns are received was 16·8 at the end of January, compared with 16·5 at the end of December. The percentage of unemployed among workpeople insured under the Unemployment Insurance Act was 16·2 on January 31, showing no change as compared with December 30. The percentages for males and females on January 31 were 18·2 and 11·2 respectively. The total number of workpeople registered at the Employment Exchanges as unemployed on January 31 was approximately 1,906,000, of whom 1,458,000 were men and 333,000 were women, the remainder being boys and girls. On December 30 the number on the live register was 1,886,000, of whom 1,451,000 were men and 334,000 were women. In addition to those unemployed, 166,000 males and 122,000 females were registered on January 31 as working systematic short time in such a manner as to entitle them to benefit under the Unemployment Insurance Act. On December 30 the corresponding figures were 178,000 males and 137,000 females. The number of vacancies notified by employers to Exchanges and unfilled on January 31 was 20,100, of which 5,200 were for men and 12,800 for women, compared with 19,200 on December 30.

Changes in rates of wages reported as having come into operation in January, in the industries for which statistics are compiled by the Labour Department, affected over 4,060,000 workpeople, of whom 3,680,000 sustained decreases and about 380,000 received increases. The net effect of all the changes was a reduction in weekly full-time wages of nearly 570,000*l.* per week. At coal mines in most of the principal districts, except the Yorkshire and East Midland area, the percentage additions to standard rates were reduced in January, the largest reductions (equivalent to about 10 per cent. to 12 per cent. on current rates) occurring in Northumberland and Durham; there were small increases, however, in the Yorkshire and East Midland, Bristol, Radstock and North Wales districts, and also in the case of some of the lower paid men in Cumberland, South Staffordshire and Scotland. Men employed in the engineering and shipbuilding trades and in various metal trades were affected by the withdrawal of the final instalment of the bonuses of 12½ per cent. and 7½ per cent., previously paid to time workers and piece workers respectively. There was a reduction of 4*s.* per week in the wages of adult male traffic workers in the railway service. Dock labourers sustained a decrease of 1*s.* per day, or 6*d.* per half-day; and men employed in gas undertakings had their wages reduced by 1½*d.* per hour, or 1*s.* per shift. There were reductions in the wages of blast-furnace workers in all the principal districts, varying from about 8 per cent. to 25 per cent. on current rates.

The number of trade disputes involving stoppages of work reported to the Labour Department as beginning in January was 57. In addition, 36 disputes, which began before January, were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in progress at any time in January (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 18,500, as compared with 14,600 in the previous month and 37,000 in January, 1921, when a dispute was in progress involving 10,000 shipyard joiners and carpenters throughout Great Britain. The estimated aggregate duration of all disputes during January was about 184,000 working days, as compared with 127,000 days in December, 1921, and 758,000 days in January, 1921.

On February 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was about 88 per cent., above that of July, 1914. The corresponding figure for December 31, 1921, was 92 per cent., and that for February 1, 1921, was 151 per cent. The decrease in the percentage since December 31 is mainly due to reductions in food prices.

PISTON RING TESTING APPARATUS.

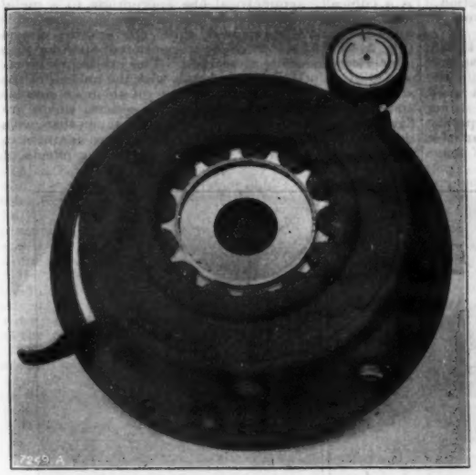


FIG. 1.

Fig. 2.

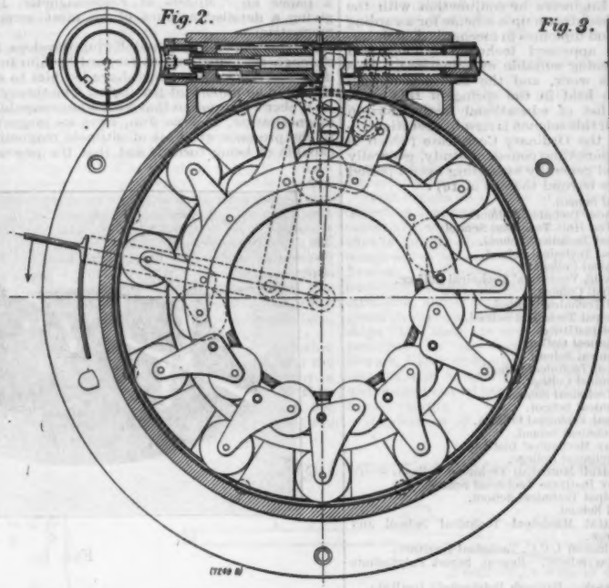
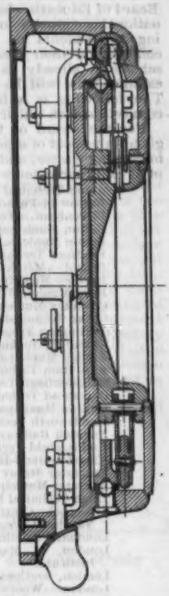


Fig. 3.



THE device illustrated in Figs. 1 to 3, annexed, has been developed by the Société Anonyme Adolphe Saurer, of Arbon, Switzerland, for the purpose of testing the piston rings of motor car and similar engines. Its object is to determine whether the pressure exerted on the walls of the cylinder when the spring is compressed to its working diameter, is within allowable limits. It is purely a comparator, as it merely indicates whether the ring being tested has the same characteristics of stiffness as some standard ring which is known to be satisfactory.

Mounted on ball bearings inside the circular casing is a steel ring having radial slots in its upper face. A number of bell crank levers are pivoted to the casing, and a roller on the outer end of each lever fits into one of the slots in the ring. The other end of each lever also carries a roller which is caused to bear upon the outer circumference of the piston ring to be tested by the rotation of the steel ring already mentioned. The latter ring carries a projecting finger which engages with a plunger situated in a sliding tube. By pressing on a lever which projects from the casing, this tube is caused to move towards the gauge shown on the drawing against the action of a spiral spring. The plunger is pressed up against a shoulder in the same direction by a spiral spring within the tube and is therefore carried along with the tube until the resistance to its further motion is sufficient to overcome the compression of the spring acting upon it. This occurs when the finger, carried along by the plunger, has rotated the steel ring sufficiently to cause the rollers to exert a certain pressure on the piston ring.

The gauge of the instrument has two concentric dials, the reading of one being due to the motion of the tube and that of the other to the motion of the plunger. To set the instrument, a steel disc of the closed size of the ring to be tested, is inserted, and the lever pressed until the rollers are in contact with it. The dial is then rotated until the pointer stands opposite a zero mark. A piston ring of standard strength is then substituted for the disc and the lever is again pressed. When this ring has been compressed to the standard diameter, the pointer will again point to zero, but before this occurs the inner dial will have been actuated by the differential motion of the plunger, and will take up a position depending on the relation between the reaction of the piston ring and the initial compression of the spring which holds the plunger up to its work. This compression is adjustable, and when the machine is properly set, the effect of closing it on a ring of standard size and strength is to bring the pointer to zero on the size scale and between two limit marks on the strength scale.

The appliance is supplied in this country by the Saurer Commercial Vehicle Company, Limited, of 21, Augustus-street, Albany-street, London, N.W. 1.

NOTES ON NEW BOOKS.

One does not wish to be too critical concerning the first edition of a comprehensive work of reference because no class of book contains more possibilities of faults both of commission or of omission. This is particularly the case when the volume deals with trade and industrial matters, in which conditions are constantly changing. But whatever allowances one makes, it is not possible to appraise *The Ship Compendium and Year Book, 1922* [Compendiums, Limited, 18, Old Compton-street, London, W.1, price 2*l.* 2*s.* net], as highly as one might wish. The work is divided into two main sections, first an alphabetical list of the names of shipping and allied firms, giving their addresses, and secondly, a directory of firms classified according to their businesses. This second section is extraordinarily defective. Turning at random to the heading of Turbine Reduction Gear, we find only three British firms mentioned, such companies as the Power Plant Company, Turbine Gears, Limited, the Metropolitan Vickers Company, &c., being unnoticed. It is also implied that no reduction gearing at all is made anywhere abroad except by one of the British firms who are established in New York. The next heading is Turbines, Propulsive, and under this we note, among others, Messrs. Turbine Gears, Limited, and Gilbert Gilkes and Co., two firms who will probably be surprised to find themselves in this category. The British Westinghouse Electric and Manufacturing Company is given as a still-existing firm, and names which spring to the mind whenever turbine propulsion is thought of are omitted altogether from this wholly misleading list. All these errors and more are included in a single column of one of the thousand or so pages of which the book is composed. Under Small Tools, we look in vain for Messrs. Alfred Herbert, Vickers or Churchill; under Power Plant we find only one British firm; under Presses, Flanging, the only British firm mentioned is the branch of an American house, and so on. We have, however, said enough to indicate the unreliability of what ought to be the most important section of the book.

Since the days of Bouguer, 1740, most gravity determinations have been carried out with the aid of pendulums, which had first been applied for this purpose by Huygens. The simple pendulum originally used consisted of a heavy bob suspended by a thread. That pendulum was of such a length as to vibrate at a slightly faster or slower rate than the clock pendulum, coincidences with which were counted. Bessel made use of a pendulum of variable length and also of mirrors for the better determination of coincidences. Later the reversible pendulums of Kater, Repsold, Peirce and others were adopted. Up till about 1880 the usual pendulum length was 1 metre, and the period one second. Then R. von Sterneck of Vienna, introduced the quarter-metre half-second pendulum which soon superseded the longer and heavier instruments. In the United States Coast and Geodetic Survey gravity work began in 1873; the half-second pendulum was adopted by Mendenhall in 1891, and was in 1909 used in 47 stations; since then the number of stations has increased to 220 and quite recently, since 1920, invar pendulum bobs have been tried in the place of platinum bobs. The gravity apparatus used in the United States, the method of taking observation and the computation of the data, are described in detail in Special Publication No. 60 of the United States Coast and Geodetic Survey [Government Printing Office, Washington, price 15 cents] by Clarence H. Swick. The platinum pendulum bob is lenticular, 9 cm. in diameter, and weighs 1·2 kg. Two small mirrors are attached to the side of the head; the suspension is by knife edges. Three of these pendulums, to be used in rotation, are mounted together with a dummy pendulum bearing the thermometer, in a brass casing or receiver, which has three windows for observing the coincidences, the amplitudes and the temperature and pressure; a partial vacuum (60 mm. pressure) is maintained in the casing. The flash box by the side of the case gives a flash whenever an electric circuit is broken; the flash box is closed by a shutter consisting of three boards. Time signals are given by chronometers and chronographs and also by radio-telegraphy. Once released by a screw from outside each pendulum swings for about 12 hours. The illustrated descriptions and instructions given in the publication are very interesting, but the title, "*Modern Methods for Measuring the Intensity of Gravity*," is altogether misleading. Apart from the few historical notes, the monograph confines itself to the instruments now in use by the United States Survey. There is no reference whatever to the various torsion balances of Cavendish, Boys, Poynting, Richarz and Krigar-Menzel, Eötvös and others, for comparative gravity determinations, nor to the special apparatus of Hecker and Duffield for determining gravity at sea. It is difficult to see how the title "modern methods" can be justified. One also thinks of gravity balances suitable for the search of metals, also a subject not alluded to.

Text-books for the use of students in the day and evening classes of technical schools are certainly not any easier to write than books for more advanced students. If the treatises are to be condensed from larger publications, the work should be done by thoroughly competent writers, and the contraction should consist in the excision of detail. Important general features should be accentuated, and too much should not be attempted. Such considerations do not appear to have guided Mr. Thomas Hull in his book on "*Oils, Fats and Fuels*" [Blackie and Son, Limited, 50, Old Bailey, E.C., price 3*s.* 6*d.* net]. Oils and fats, even excluding petroleum, would have been quite enough for a small volume of 145 pages. When the student referred to is to be provided with a text-book on oil and fats, he should be told something about solubility, viscosity, flashpoint, drying power, oxygen absorption and iodine number; most of these terms are not mentioned at all. So-called questions at the end of the chapters, such as: Name two fish oils and two blubber oils; give the chief properties of crude petroleum; for what purposes can liquid fuel be used as a substitute for coal? will not teach the student anything. An alphabetical index and more information would be far more welcome.

NATIONAL CERTIFICATES AND DIPLOMAS IN MECHANICAL ENGINEERING.

IT has been known for some time now that the Institution of Mechanical Engineers in conjunction with the Board of Education had drawn up a scheme for awarding national certificates and diplomas in mechanical engineering to students of approved technical schools and colleges, on their passing suitable examinations. This scheme is already at work, and the first set of final examinations will be held in the spring of this year. The following is a list of educational institutions in connection with which this scheme is now in operation :—

For the award of the Ordinary Certificate (which is given in respect of a part-time course of study, generally in evening classes, and generally extending over a period of at least three years beyond the age of 16) :

Aston Technical School.
Barrow-in-Furness Technical School.
Birkenhead.—The Holt Technical School.
Bolton Municipal Technical School.
Bootle Municipal Technical School.
Bradford Technical College.
Bristol.—Merchant Venturers' Technical College.
Burnley Municipal College.
Bury Municipal Technical School.
Coventry Municipal Technical School.
Crewe Technical Institute.
Darlington Technical College.
Dewsbury Technical School.
Dudley Municipal Technical School.
East Ham Technical College.
Gainsborough Technical School.
Gateshead Technical School.
Halifax Municipal Technical College.
Handsworth Technical School.
Horwich Railway Mechanics' Institute.
Huddersfield Technical College.
Kingston-upon-Hull Municipal Technical College.
Lancaster Storey Institute Technical School.
Leicester Municipal Technical School.
Leigh Technical School.
Liverpool Central Municipal Technical School and Nautical College.
London.—Paddington L.C.C. Technical Institute.
London, St. Marylebone.—Regent Street Polytechnic Institute.
London, Southwark.—Borough Polytechnic Institute.
London.—Woolwich Polytechnic Institute.
Loughborough Technical College.
Manchester College of Technology.
Middlesbrough High School.
Newcastle-on-Tyne.—Rutherford Technical College.
Newport (Mon.) Technical College and Institute.
Nottingham University College.
Oldham Municipal Technical School.
Preston.—Harris Institute.
Rugby Technical School.
Salford Royal Technical College.
Sheerness Technical Institute.
Sheffield University.
Shrewsbury Technical School.
Smethwick Municipal Technical School.
Southport Technical School.
Stoke-on-Trent Central and Branch Technical Schools.
Sunderland Technical College.
Swindon and North Wilts Technical Institution.
Wallsend Secondary School and Technical Institute.
Walsall Municipal Institute.
Wednesbury County Technical College.
West Hartlepool Technical College.
Widnes Municipal Technical School.
Wigan and District Mining and Technical College.
Wolverhampton Municipal Science and Technical School.
Workington County Technical and Secondary School.

For the Higher Certificate (which is given under similar conditions to that for the ordinary certificate, but in respect of a subsequent and more advanced course of study extending over two or three years) :

Barrow-in-Furness Technical School.
Bradford Technical College.
Halifax Municipal Technical College.
Huddersfield Technical College.
Liverpool Central Municipal Technical School and Nautical College.
London, Southwark.—Borough Polytechnic Institute.
London.—Woolwich Polytechnic Institute.
Manchester College of Technology.
Newcastle-on-Tyne.—Rutherford Technical College.
Nottingham University College.
Oldham Municipal Technical School.
Preston.—Harris Institute.
Salford Royal Technical College.
Sunderland Technical College.
Wigan and District Mining and Technical College.

For the Ordinary Diploma (which is given in respect of a full day-time course extending over two or three years) :

Brighton Technical College.
Cardiff Technical College.
London, St. Marylebone.—Regent Street Polytechnic Institute.
Manchester College of Technology.
Newcastle-on-Tyne.—Rutherford Technical College.
Newport (Mon.) Technical College and Institute.
Salford Royal Technical College.

For the Higher Diploma (which is given in respect of a full day-time course extending generally over three years and reaching the standard of an engineering degree) :

Brighton Technical College.
Halifax Municipal Technical College.
Nottingham University College.
Sunderland Technical College.

SOUTH AFRICAN PAPER-MAKING PROJECT.—A company is being formed in Natal to undertake the manufacture of wrapping paper from wattle wood and spent bark from the wattle extract mills, states the *South African Journal of Industries*. A process is reported to have been discovered by which excellent wrapping paper can be made from these materials. It is proposed to make later newsprint paper from wattle bark combined with tambuki grass, and also cardboard for the manufacture of fruit and egg boxes from spent bark.

MODELS OF FERRO-MAGNETIC INDUCTION.

AT the Royal Society of Edinburgh, on February 20, Sir J. Alfred Ewing, K.C.B., F.R.S., vice-president, read a paper on "Models of Ferromagnetic Induction," giving a detailed account of his most recent work in magnetism.

In this paper Sir Alfred Ewing develops the theory of magnetic induction put forward by him in 1890, and discusses the reasons which have led him to modify the theory in an important particular. The theory was based on Weber's conception that a substance capable of strong magnetisation, such as iron, owes its magnetic quality to the presence within it of ultimate magnetic particles capable of being turned, and that the process of magnetising consists in compelling these particles to face more or less completely in one direction. When all the Weber particles are facing one way the iron is magnetically saturated. What the author showed in 1890 was that the control under which the Weber particles turned was a magnetic control, and that in turning they fell over from one position of stable equilibrium to another, through an unstable phase, thereby producing the phenomena of magnetic hysteresis. This fundamental feature of the theory is retained, but the author has now abandoned his further idea that the control of the particles was due simply to their mutual magnetic forces, acting from atom to atom, because a quantitative examination of the forces produced in that way has convinced him that other forces are also involved. These other forces are those which exist within each individual atom, between the Weber particle and the rest of the atom. We now know the atom to be a very complex whole, comprising many moving electrons. In a substance such as iron each atom contains a Weber particle, a thing that turns under the influence of an external magnetising force. It is not the atom as a whole that turns, but only a part of it. According to the author's view there is magnetic control exerted between the part that turns and an outer shell which is held fixed in relation to neighbouring atoms. He now shows that all the characteristics of the magnetising process can be accounted for on this basis, and may be reproduced by means of illustrative models.

The first part of the paper is a study of the equilibrium of pivoted magnets, undertaken with reference to the author's model of 1890, in which the Weber particles were represented as rows of little magnets controlling one another by their mutual forces only. It is shown that this model fails quantitatively because when the magnets are placed near enough together to give the correct form to the curve of magnetisation, in its several stages, the deflecting force which is required to break up the row is enormously greater than that which suffices to produce strong magnetisation in iron. The stability of the row is far too great. In the new model the stability can be reduced to any desired extent, for it depends on the balance of attracting and repelling forces due to the action of opposite portions of the outer shell of the atom on the Weber particle within. Several forms of the new model are described, some with pivoted magnets to represent the Weber particles and fixed magnets to represent the controlling portions of the atomic shell. Thus in the model of Fig. 1 a pivoted magnet in the centre turns between four fixed magnets, all of which present towards it poles of the same name. In the model which is shown in Fig. 2, the Weber particle is a group of eight magnetic poles, turning as a whole within a group of eight fixed magnets. The arrangement is a cubically symmetrical one appropriate to a metal such as iron, in the crystals of which the space-lattice is known to be the centred cube. In another model (Fig. 3) the Rutherford-Bohr conception of an atom with large electron orbits is realised. The orbits are represented by elliptically-shaped coils with the nucleus of the atom at their common focus : one of them is circular and turns under the control of the others, which are fixed. Sir Alfred Ewing went on to show that with these models it is possible to imitate known features in the magnetic behaviour of metals, including effects of stress and temperature. It was pointed out that the new model preserves all the advantages in this respect of his model of 1890, and at the same time escapes the quantitative discrepancy which had made it necessary to amend the former theory.

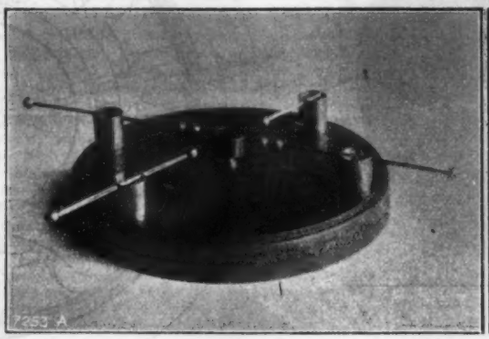


FIG. 1.

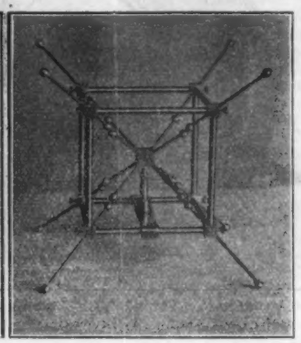


FIG. 2.

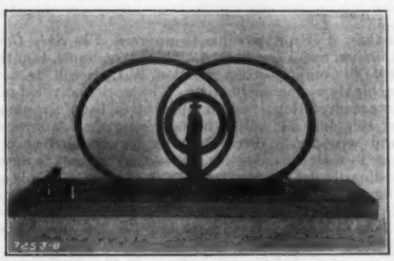


FIG. 3.

THE LATE PROFESSOR FRIDOLIN BECKER.—Dr. Fridolin Becker, engineer and professor of topography and cartography at the Federal High School at Zürich, who died on January 24, was for nearly forty years connected with the Federal Topographical Bureau of Switzerland. Born in 1854 at Linthal he was trained as engineer at the Zürich Polytechnic, where the topographer Johannes Wild, the geologist Albert Heim and the painter M. Ulrich befriended him and influenced him in the selection of his special pursuit. His work as topographer began in 1876, and he surveyed many mountain groups, glaciers, &c., of Switzerland, studying their geology and doing his best to make his maps and relief models and panoramas as instructive as possible. His relief map of the Tödi group was on the scale 1 : 50,000, that of the Canton Glarus on the scale 1 : 25,000. One of his chief associates in this work was his friend Xaver Imfeld, who died in 1909. Becker's doctor degree of 1914 came from the University of Lemberg (Lwow) in honour of his arbitration on the boundary in the High Tatra between Austria and Hungary. His artistic relief maps more than once prevented industrial enterprise endangering beautiful scenery, and he thus made many friends and a few enemies. Becker was a colonel in the Génie Corps of Engineers of the Swiss Army and a member of the general staff.

THE RUTHS SYSTEM OF STEAM STORAGE.—In recent careful experiments made with a water tube boiler provided with a superheater, Professor Josse found at Charlottenburg that, at strongly fluctuating load, the mean performance of the boiler was by 22 per cent. smaller than at uniform load, so that fluctuating loads would necessitate a larger boiler plant than would otherwise be required. To get over that difficulty, Dr. Ruths, a Swedish engineer, makes use of large steam storage vessels, novel not so much in themselves, as in the method of their insertion in the distribution system. The Ruths steam storer is generally a large horizontal boiler, well lagged, filled to nine-tenths of its volume with water. Steam enters the water through two valves, and a horizontal pipe below the water level, and is discharged through a series of nozzles into an equal number of ejectors ; the steam leaves the storer through a dome and a Laval nozzle which only allows a limited amount of steam to flow out. In the case of a turbine-driven electric power station the storer would be coupled between the high-pressure and the low-pressure turbine. The high-pressure steam supplied by the primary boiler flows through the high-pressure wheels, which reduce the pressure say from 20 to 2 atmospheres, and then partly into the storer and into the low-pressure system. Between the high pressure side and the storer there are two valves, which can be controlled from different parts of the installation. There are more than 50 installations of the Ruths system in electric power stations, blast furnace plants and other works of Sweden and Finland. The Ruths storers have not yet been introduced elsewhere, but are favourably commented upon by Dr. G. Schulz on behalf of the Engine Committee of German Iron Masters in *Stahl und Eisen* of February 2. The illustrated article explains the connections ; when steam engines are used instead of steam turbines, the storer is interposed between the low and high-pressure cylinders.

ELECTRIC WELDING.

*Electric Welding Applied to Steel Construction, with Special Reference to Ships.**

By A. T. WALL, of Liverpool.

THE object of this paper is to call attention to the various ways in which electric welding is being applied to ship construction, and to indicate further possibilities in this connection for steel structures. Reference is also made to the necessity of taking reasonable precautions in carrying out his work.

Electric welding is now approved by registration societies for the survey of shipping for strength parts of a ship structure. This may be said to be the greatest step made in this branch of industry. Electrically-welded barges have been built, and also the all-welded motor ship Fullagar. The latter ship has demonstrated that an electrically-welded vessel can carry out successfully the work of a sea-going carrier. It requires little imagination to see the great advantages obtainable by the application of electric welding, as compared with the usual method of riveted connections.

Before entering into the possibilities of the electric welding of large structures such as ships, it will be advisable to consider in detail their structural design with particular reference to the joints and attachments of the component parts.

Riveted Joints.—When ships were built of wood, a great amount of otherwise redundant material had to be used in order to provide the necessary strength at the joints of the timbers. With the advent of iron ships, rivets became the recognised means of making the joints, and it became possible to give these joints a greater percentage of strength than those of the wooden vessels. Mild steel eventually displaced iron, but the riveted joint remained practically unaltered.

It has always been an axiom in designing iron or steel structures that nothing is stronger than its riveted connections. The weakest part unavoidably occurs where most fastenings are necessary. Consequently the material often has to be further weakened by holes for additional fastenings before it can be strengthened by doublings. As far as possible, the scantlings of a structure are fixed to take account of these facts.

There are many obvious disadvantages attached to the use of rivets. In the first place, the steel plates and bars must be punctured to take the rivets, and are thereby weakened. Such weakening occurs, for example, where a frame or a boundary angle of a bulkhead is riveted to the shell plating. Fig. 1 shows part of a typical shell plate of a ship, with all the necessary rivet holes indicated, all of them being countersunk. Assuming, as is usual, that the plate is weakened in direct proportion to the area punched out for the holes, and allowing for the hole being larger than the rivet and for the countersink, it will be observed that the strength through a line of frame rivets A A is 78 per cent. of the intact plate, while through a line of bulkhead rivets B B it is only 74 per cent., calculated on one row, and by the close proximity of the other row is probably a good deal less than this. In the second instance provision is sometimes made for increasing the strength by fitting a doubling plate. This is used in war vessels, where the bulkhead rivets are more closely spaced, but not in merchant ships, where brackets are fitted on each side of the bulkhead as compensation. Doublings, however, are not ideal, and they also are riveted on. They often produce an undesirable concentration of stress, and cost money in labour and material.

The assumption that the plate is weakened only in direct proportion to the area punched out for the rivet holes is not borne out by the experiments of Professor Coker and those of Mr. J. S. Wilson and Mr. W. Gore. Their experiments show that the stress at the edge of the rivet holes is greater than the mean stress. Professor Coker's figures show about 45 per cent. increase above the mean, and Messrs. Wilson and Gore show about 70 per cent. above the mean. These are for particular cases, and the figures would not be directly applicable generally, but the results show that, in effect, a rivet hole weakens the plate to an extent greater than indicated by the plain reduction of area. In merchant practice, to simplify labour, especially of riveting, the joints of plates are overlapped. They are usually made as shown in Fig. 2. It is apparent that the pulls transmitted in the plane of the plates must produce a bending of the plate near the edges of the laps, which is not advantageous.

Some important and interesting experiments have been carried out on riveted joints by Dr. J. Montgomerie, chief surveyor to Lloyd's Register in Scotland, and the results were given in a paper before the Institution of Engineers and Shipbuilders in Scotland in 1919. These experiments showed that the strength of a treble-riveted overlapped joint is about 67 per cent. of the intact plate, and of a quadruple-riveted overlapped joint about 72 per cent. The latter may be taken as being the most efficient overlapped joint, and is to be compared with the figure of 74 per cent. already given, which, as pointed out, probably has a smaller value. This form of joint, therefore, is roughly sufficient for the purpose, but the fact remains that, from main stress considerations, only about 72 per cent. of the material in the plate is effective, because of the use of rivets.

When very special strength is required, or for other reasons, flush joints with riveted straps are used, and the strongest form of this type in general use is shown in Fig. 3. This is common in war vessels. With this, theoretically, about 81 per cent. of the strength of the intact plate is obtained, which is somewhat greater than the strength of the plate through the line of frame rivets.

Other experiments that the author has seen carried out on riveted joints show that the watertight caulking opens at very low stresses. For flush-riveted butts with single straps treble-riveted (Fig. 3), a stress of 3 tons to 4 tons per square inch is sufficient to open the caulking so as to render the joint non-watertight, especially under pressure. With less efficient straps this stress is, of course, less. With lap-joints, especially on account of the bending action, one would certainly not expect the stress at which caulking opens to be anything greater than the above figure, and this would seem to be borne out by the experiments of Dr. Montgomerie just referred to.

Cases of failure by breaking under tensile stress do occur, but these are invariably due to concentration of stress brought about by a bad distribution of material. Riveted joints generally remain watertight in practice, which appears to indicate that they are not unduly stressed. In no case, therefore, with rivets, is it possible to make full use of the material worked into a structure for strength purposes. This is obviously an undesirable state of affairs, and electric welding in the place of rivets offers an immediate advantage in giving a jointing and connecting medium which allows the use of practically cent. per cent. of the material for strength purposes. If this be so, it follows, at any rate theoretically, that welded joints can be made as strong as the materials they join, and that there is no necessity to lose any of the strength of this material by puncturing it.

Many practical considerations enter here, which make it impossible to obtain this ideal state, but there can be no doubt that a far greater amount of the material can be made effective by the use of welding than by riveting and doublings can be made more efficient.

It follows from this that the whole system of shipbuilding can be remodelled, because :—

(1) Vessels can be built of more extreme dimensions, with great advantage, say, where draught is limited.

(2) Lighter scantlings can be used.

(3) For high-speed vessels a flush surface can be given to the shell plating and eddy resistance reduced.

(4) Framing can be made much lighter and yet stronger, since by welding, frames can be made to the shape of the ideal economical girder; such a girder as one would cast for example, if possible. This would be brought about by the absence of plate flanges and riveted connections between the component parts of the frame girder.

(5) Simpler and more efficient joints can be made, and continuity of strength can be maintained in members crossing one another, which is not possible with riveted connections.

(6) Complicated smithed collar work can be practically eliminated.

(7) Stiffening, whether principal or local, can be used to greater advantage.

(8) Better oiltight and watertight work can be guaranteed.

It is not, however, considered desirable to eliminate rivets entirely, and the holes for them would also be used for erecting and closing purposes.

With regard to the use of lighter scantlings, the chief objection that can be raised to this is the strength of the material under compression. It may be said in a ship that failure by absolute crushing cannot happen, but the compressive stresses may produce failure by secondary flexure. The answer to this is that no failure has yet occurred in this manner with vessels of ordinary construction, and it is generally admitted that greater compressive stresses can be transmitted by the plating of ships than they are ever called upon to bear in present practice. In any event such failure by secondary flexure, likely to happen with greater compressive initial stresses, can be overcome by the use of extra stiffeners, which need not be heavy or difficult to apply if welded on to the plating.

Application of Electric Welding.—The first all-welded vessel to be built in this country was a barge at Richborough, which was 126 ft. long, 16 ft. 4 in. in breadth, and 7 ft. 6 in. in depth, and was welded by Royal Engineers with quasi-arc electrodes. This was followed by a much more important vessel, the motor-ship Fullagar, welded by the same process, whose dimensions are: Length, 150 ft.; breadth, 23 ft. 9 in.; depth, 15 ft. 6 in. This vessel has been somewhat fully described elsewhere, but it is interesting to recall that she was built to the classification of Lloyd's Register, and may be said to have arisen out of a series of experiments on welding, also with quasi-arc electrodes, carried out by Lloyd's Register of Shipping. These experiments have been fully described by Sir Westcott Abell.* The late Sir George Carter, the managing director of Cammell Laird and Co., decided to give the welding an extensive trial by constructing the Fullagar, and the shipbuilding industry owes him a great debt for this. The author was intimately associated with these experiments and with the Fullagar, as naval architect to Messrs. Cammell Laird and Co.

Special attention was given in the Fullagar to the design of the joints, so that they might be suitable for the application of welding. These have been described in ENGINEERING, July 2, 1920.

Preparation and Erection.—It was found in the work on the Fullagar that the best results would be obtained by carrying out as much of the welding as practicable in the shops. For this reason the parts were designed so that they could be welded together in as large pieces as possible before leaving the shops. The advantages of this procedure are many. In the first place, welding can proceed independently of the weather; and, secondly, material can be turned over so as to avoid the necessity of overhead welding; and, thirdly, it is possible to give the work better supervision, both from the point of view of efficient welding and the output of the men. In order to erect the material at the ship it was found necessary to use service bolts. The holes for these were spaced at good intervals, generally about 3 ft. 6 in. apart.

In order to make the corresponding surfaces of the

Fig. 1. TYPICAL OUTER BOTTOM PLATE.

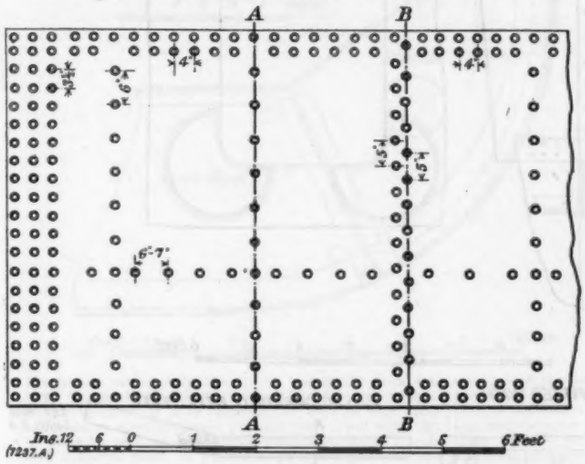


Fig. 2. JOINTS OF PLATES OVERLAPPED FOR RIVETING.

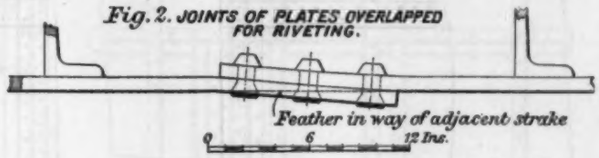
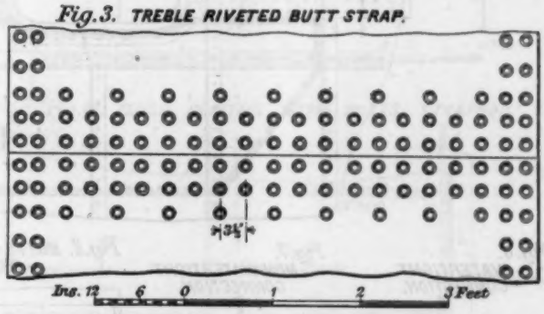


Fig. 3. TREBLE RIVETED BUTT STRAP.



* Paper read before the Institution of Mechanical Engineers, on Friday, February 17, 1922.

* "Experiments on the Application of Electric Welding to Large Structures." Proc. Inst.C.E., 1919.

materials "fay" closely, use was made of angle-iron strong-backs inside and out, fastened by the service bolts, and the material was brought together by the use of steel wedges driven underneath these strong-backs. The bottom shell plating was first erected and "shored up." Afterwards, floors were placed in position. These had temporary lugs welded on, and the shell flange of the lug was bolted to the shell plates through seams. These bolts were used for fastening the strong-backs; the lugs were eventually cut away. The plate edges should not be planed, as the sheared edge facilitates the welding.

It was found possible to train men as welders in a matter of two months or so, but some men showed much better aptitude for it than others. When a man had once proved himself efficient, it was generally found that his work was always satisfactory and gave no trouble.

The Fullagar has been in service for some eighteen months and the welding has proved itself to be highly satisfactory. The vessel has carried several cargoes of steel plates and similar material, and has encountered very heavy seas without showing any signs of failure in the welded joints. She also received a minor indent on her side, without starting the welding. She was recently examined by Lloyd's and found to be in good condition. No strains appeared at the break of the quarter deck, as usually happens with rivetec vessels of this class.

Weight of Structure.—The Fullagar was undoubtedly treated in the nature of an experiment, with the result that although the welded joints, especially the butts of the plating, were given cent. per cent. strength and the plates were intact and unpierced by the rivet holes (the service bolt holes were welded up solid, practically making up the original strength), no attempt was made to cut down the scantlings of the steel. In spite of this there was some saving of weight brought about by a smaller amount of overlapping of the plates and by the omission of some angleiron connections, and also by flanging plates where normally an angle-iron would have been fitted. The saving of weight in this way amounted to approximately 5 per cent. of the total weight of the steel in the ship. This, of course, results in a gain of deadweight carrying capacity, although small.

Cost.—It can at once be said that the cost of the Fullagar was greater than if she had been a riveted vessel, but there were many factors to account for this, and it was not found possible to arrive at even a comparison of cost between the two methods if normal conditions prevailed.

In the first case, the welders had to be trained, and, in accordance with the practice of the shipbuilding industry, the trade or trades affected by the adoption of a new tool had to be given the option of using that tool. Whether this should have applied to electric welding, which, outside of the shipbuilding trade, was being done by "trained welders," who were generally not taken from the skilled trades, is quite an open question. However, the work was given to the platers, riveters and caulkers who were the three principal trades affected, and men of each of these branches of the Boilermakers' Society were initiated into the use of the electric welding apparatus.

This training was most expensive because:—

(1) From the commencement these men were paid an enhanced day rate approximating to their earnings as if they were employed on their ordinary vocations under "piece work" conditions.

(2) A number of the earlier trained men, as soon as they became efficient, migrated to other districts where there was a demand for skilled welders, and consequently other men had to be trained.

(3) Soon after the actual construction of the work commenced, claims by the operatives were made and insisted on by their trades union representative, which were in themselves sufficient practically to make the cost of welding prohibitive. Amongst these were (a) not less than two men should be employed on a cable or welding set, and that all these men should be members of the Boilermakers' Society, ordinary helpers not being allowed. (b) Each of these men should be paid the welder's rate. (c) No apprentices should be allowed to work as electric welders.

In addition to these, various other claims as regards supervision, extra pay above the welder's rate for certain work, &c., were made, and several times a complete stoppage of work was threatened, the experimental nature of the work to a certain extent creating new demands which could not be refused without creating a dispute which might affect the industry as a whole. This at the time was most undesirable.

In addition, the vessel was built at a very difficult time, when the supply of steel was small and uncertain, and prevented the preparation of the plating and framing being carried out economically, so that the saving that should have been made owing to the small amount of punching and template work was not what it should have been.

The vessel remained a long time on the stocks, principally owing to the exigencies of other work, and this always runs up cost. It is also true to say that certain parts of the ship would have been more cheaply constructed with riveted connections, but in view of the fact that the vessel was to be all welded, this was not done. It can still be added that extra cost was incurred on account of the pioneer nature of the work.

Various Applications.—The numerous applications of electric welding for carrying out repairs are well known. These have been applied generally to non-structural parts, and not to the parts which take up the main stresses of the ship. In this connection reference can be made to repairs on cracked stern posts, the biggest repair of this kind being carried out on the battleship Ramillies. Also, repairs to shaft brackets, stern tubes, cracked plates, studs in the hard surface of armour plates, and pipe work. The application of electric welding to main strength parts of a ship's structure raises an issue of far greater importance.

Openings in Superstructure.—The author is indebted to Professor P. Hillhouse, D.Sc., chief naval architect to the Fairfield Shipbuilding and Engineering Company, for a description of his system of strengthening openings in the superstructure of ships. Large openings are necessary for doors and windows, and many failures have occurred through cracking taking place at their corners. This happened in spite of, and perhaps assisted by, doubling plates riveted on.

The usual riveted doubling to an opening is shown in Fig. 4. It will be noticed that the main plate is pierced by rivet holes, and the crack usually runs through one or more of these, which assist in its formation. Dr. Hillhouse has applied welded doubling pieces at the corners, of much less area and as shown diagrammatically in Fig. 5, and they have received the approval of the British Corporation.

Deck Openings.—Reference has been made to concentration of stress. This occurs particularly in the upper and strength decks. It is very marked in vessels with wide hatch openings. A glance at these hatch corners reveals large doubling plates with girders underneath, and one is struck by the enormous number of rivets. Most of these are "three-ply," and some "four-ply," an undesirable happening, to say the least. Similar arrangements are made at corners of deck openings for machinery casings. It is at these places that failures sometimes occur, and the application of welded doublings, as for superstructure openings, would be more effective and cheaper.

Angle-bar Connections.—Angle-bar connections to two

OPENING IN SHIPS SIDE

Fig. 4. DOUBLING PLATES SHOWN CROSSHATCHED

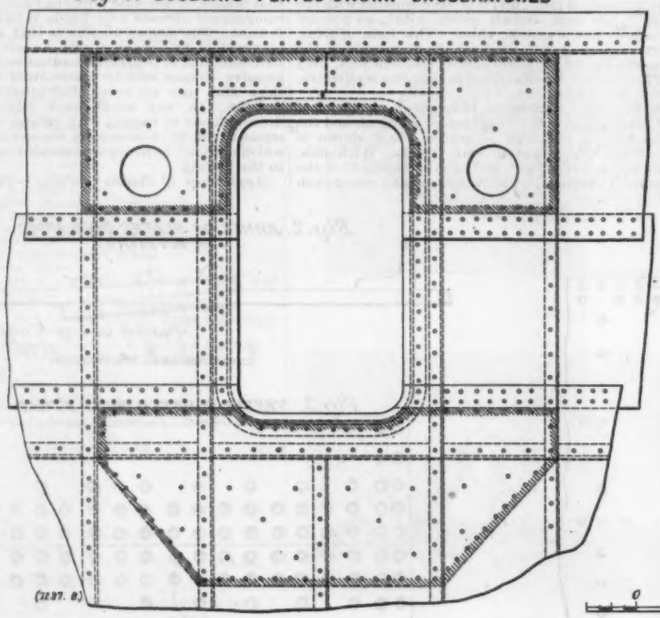
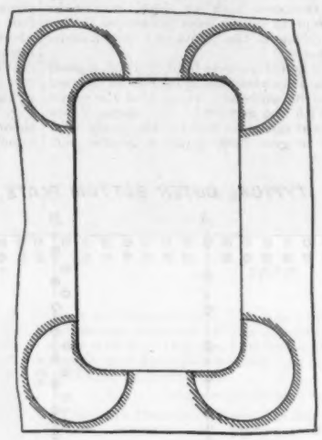


Fig. 5. WELDED DOUBLING PIECES AT THE CORNERS (Dr HILLHOUSE)



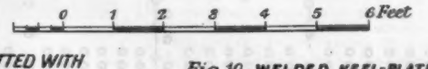


Fig. 6. WATERTIGHT CONNECTION.

Fig. 7. NON-WATERTIGHT CONNECTION.

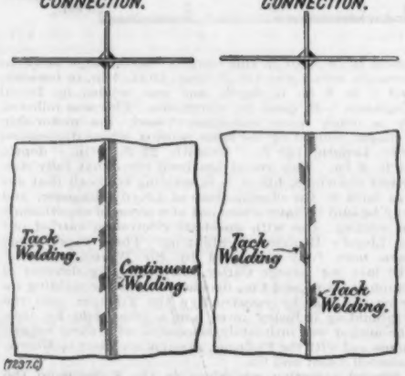


Fig. 8. BUTTS OF ANGLE-BARS FITTED WITH "BOSOM" PIECES.

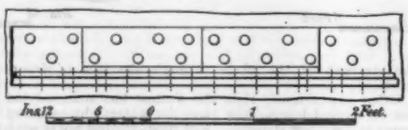


Fig. 9. ANGLE-BARS WELDED AT THE BUTTS.

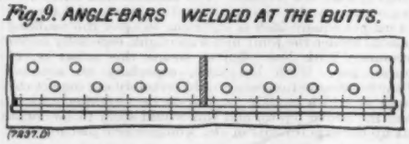
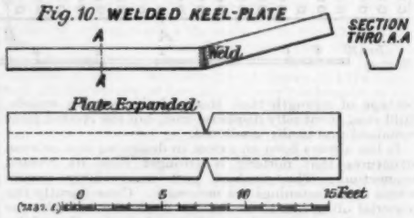


Fig. 10. WELDED KEEL-PLATE



plates more or less at right angles have obviously been brought about entirely to suit riveting. They can in most cases be dispensed with by welding the plates together directly (Figs. 6 and 7). This arrangement is capable of extensive application. In the all-welded Fullagar, for instance, the floor and keelsons plates have no angle-bar connection to the shell plating or to one another.

Butts of Angle-Bars.—Many of the "strength" angle-bars require to have their strength maintained at the butts. The practice is to fit "bosom" pieces, as shown in Fig. 8. The "bosom" piece requires fitting into the root of the main bar, and must be caulked all round for watertight work. They are rarely satisfactory. This joint can be very effectively and cheaply made by a small amount of electric welding. Fig. 9 shows this, the plates forming a convenient backing for the welding. Such a joint is as strong as the angle-bar itself, and stronger than the bar through a rivet hole.

It is always difficult to secure effective watertightness where continuous members pass through a watertight deck or flat. Complicated "smith's" work in forming angle-collars is costly and not really efficient. This difficulty has been frequently overcome in submarines and other war vessels by welding. In merchant vessels the frames are usually cut at the watertight deck and large brackets fitted on each side of it to take the frames. Watertightness is also difficult to obtain here, and necessitates several special precautions. This work can be done by welding, and with a smaller outlay of labour and material than at present. The keel-plate at the cut-up of the stern has an awkward shape, and involves much furnacing. Successful application has been made of welding here, dispensing with most of the furnacing and the extra thickness allowed for furnacing (Fig. 10).

Angle-Lugs.—Short pieces of angle-bars are required all over a ship. It is very easy to weld these on to the plate in the shop. This obviates "marking off" the plate and the lug for the holes, saves punching both, and the welding can be done in the most favourable way possible, since the parts can be placed suitably for this purpose. For example, the lugs to tank side-brackets and margin plate (A in Fig. 11) and floor lugs to margin plate (B in Fig. 11) come under this category.

Stiffening Bars.—Reference has already been made to the use of stiffeners on plates. In present practice it is necessary to produce a compromise between the spacing of stiffeners and the thickness of plating, so that the extra labour involved by fitting stiffeners does not outweigh the saving in plating weight brought about by reduced stiffener spacings. The introduction of welding alters the relation existing at present, because as mentioned above, stiffeners can be cheaply attached by welding. The ordinary stiffener is applied inefficiently solely on account of having to give it the necessary riveted connection. It is much more efficient when applied in the reverse way, as shown in Fig. 12, and this can easily be done in many cases when welded on.

Professor T. B. Abell, in a paper entitled "A study of the Framing of a Ship."* showed the value of simple angle-bar stiffeners, with particular reference to shell and tank top plating. All these can be welded on cheaply before the plates are erected, and as shown in the preceding paragraph.

Transverse versus Longitudinal Strength.—Much has been heard recently of longitudinal as against transverse framing, the title being applied to the framing which is continuous; the other is of necessity intercostal when connections are riveted. The inutility of such intercostal members is now generally accepted. One of the arguments used by Professor Abell was for the suppression of these longitudinal intercostals and the use of stiffening bars in their place.

Transverse and Longitudinal Strength.—Numerous suggestions have been put forward recently for getting a good arrangement of bottom framing, but they are practically all open to criticism on account of the intercostal nature of some of the parts. With welding, a distinct advance is possible because both transverse and longitudinal members can be made, in effect, continuous. Reference to Figs. 6 and 7 shows clearly how this can be done. The all-welded ship Fullagar is in fact framed both on the transverse and longitudinal systems. Such a possibility will enable scantlings to be reduced in many vessels.

Beam Knees.—The importance, or even necessity, of beam knees, especially on decks low down in the ship, is problematical; but there is no doubt that they are often difficult to fit and involve awkward riveting. They also cause broken stowage of cargo, and spoil the decorative effect in passengers' rooms. Here again welding offers an easy way out, and beams could be welded to frames without beam knees.

Flush Plating.—Deck, tank top and other plating is overlapped in merchant practice because flush plating with straps involves more riveting. Welding lends itself very well to flush plating. Two sister ships, 350 ft. long, of 5,000 gross tons, have had their upper deck plating welded and riveted as shown in Fig. 13, also their inner bottom plating, to the approval of Lloyd's Register. The strength of the welded joints is as great as that of the intact plating, and therefore more than ample for the strength through the beam rivets. In any case, a flush butt is stronger than a lapped one, because there is less bending under load. The rivets on one side of the joint enable service bolts to be used for closing the work before welding, and obviate the necessity for overhead welding on that side of the butt strap. The vessels thus fitted were built in Spain. In one, 450 ft. long, for French owners, the same system has been used for the poop deck plating. Unfortunately, experience of labour in this country shows that the union would probably demand as much for the riveting of the few rivets in the joint as if it was wholly riveted. It is to be hoped that this attitude will be altered.

The incidental advantages of flush plating are many. If a wooden deck is laid, say 3 in. thick, at the butt overlaps, its thickness will only be 2 in. or 1½ in. With flush plating, therefore, a thickness of 2 in. should be sufficient. This effects a large saving in material and labour on the wood deck. Practically everything placed on the deck can be laid more cheaply, owing to the absence of filling pieces, &c., which involve extra material and labour. Deck plating could be most effectively and cheaply laid transversely with the plate edges on the beams. The butts would be strapped, Fig. 14. Flush plating on tank tops practically eliminates pockets for the accumulation of water and oil, diminishing corrosion and, with oil, the danger of fire, and simplifies the laying of hold ceiling.

Oil Fuel.—It is always difficult to obtain oil-tightness, especially with three-ply riveting. Without going into details it can be said that welding will obviate this form of riveting or make it good.

Water Testing.—This is always a large item in a riveted ship. It is practically negligible with welding, and results in a great saving of cost; there is also no need to use the ordinary "stop-waters" as with some riveted joints. No trouble was experienced with the water-testing in the Fullagar. After a compartment has been tested, various minor fittings have to be attached. There is always some uncertainty with regard to the final watertightness where these are riveted. When welded on, no possible doubt can arise. Under this can be included bilge keels and rubbers.

Where a ship has stresses large enough to require special strength at the joints, as, for example, in large battle cruisers, welding lends itself admirably and enables straps to be dispensed with. In H.M.S. Hood it is estimated that the shell plating weighs about 3,000 tons and full 20 per cent. of this is taken up by edges and straps.

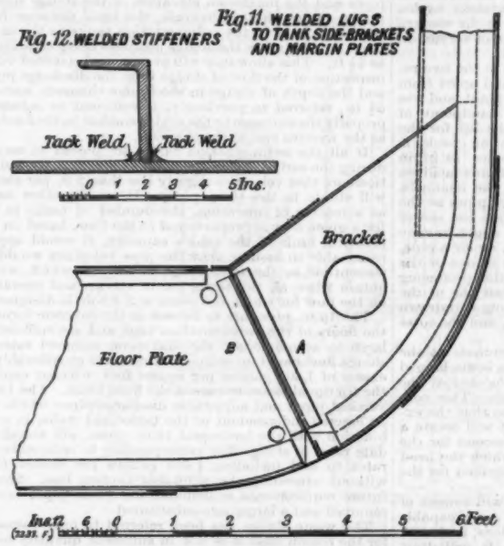
Miscellaneous.—A cheap method of attaching plates to, say, beams, is by filling in a countersunk hole in the plate by welding directly on to the flange of the beam, which has no hole in it. This connection has been tested and found to be nearly as strong as a rivet. Bad rivet holes can be filled by welding and a new hole drilled either clear of the welding or through it.

The plating and framing of the shaft bossing of merchant ships, make a very awkward riveted construction. The material could be welded to give better results in every way. Collaring around deck-houses could be dispensed with, in the main, if welding was employed. Sole plates on pillars have often been welded on. Masts and derricks would readily lend themselves to electric welding.

Plates that are welded have a tendency to creep and shift during the process. This occurred in the Fullagar at first, but was overcome as experience was gained by making the necessary allowances, but there is no doubt that here experience is necessary. Edges cut by the oxy-acetylene flame do not allow good welds to be made and in the Fullagar use of the oxy-acetylene flame was forbidden.

Conclusion.—Probably enough has been said to show that there is very ample scope for the application of electric welding to the structure of a ship, or to any other steel structure. The details should be worked out by co-operation between the office and the yard. It would result in more efficient structures because of better joints and this with less material. If judiciously applied the cost need not be greater than with riveting. This is especially true, if, as it should be, the increased earning capacity of a vessel, due to increased deadweight, is

*Trans. Inst.N.A., 1921. ENGINEERING, vol. cxi, page 376.



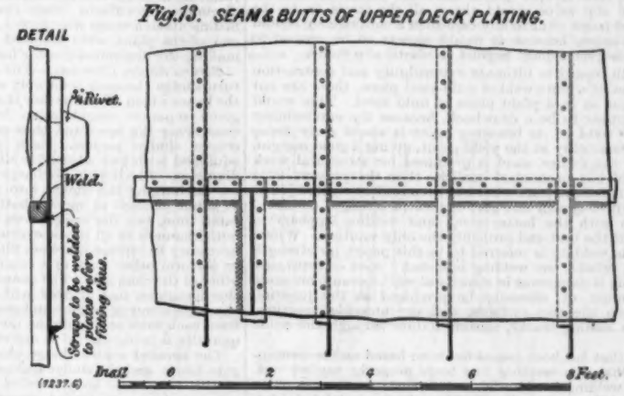
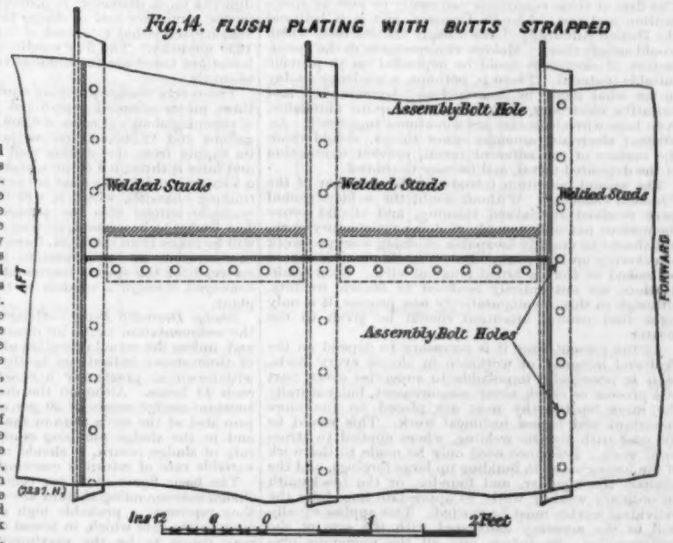


Fig.13. SEAM & BUTTS OF UPPER DECK PLATING.
DETAIL
¾ Rivet.
Weld.
Straps to be welded to plates before fitting deck.
(1237.G)
Inch 0 2 4 6 8 Feet.



taken into account, since first cost is by no means the only consideration. It would be expected that there should also be a reduced upkeep cost. Necessary repairs by damage should not be difficult, as welding plants are now to be found all over the world. The saving of weight is of particular value in warships and high-speed merchant ships, such as channel steamers, because the horse-power required to propel them can be considerably reduced. In a modern battle-cruiser, for example, every ton saved on any particular item results in a saving of 3 tons or more in the total weight of the vessel. This saving of weight is also important in any structure which has to carry its own weight. Experiments show that the strain in a welded joint is practically identical with that in the mild steel, up to the yield point. A riveted joint up to its elastic slip value behaves in the same manner. This latter is approximately one-half the yield stress of the mild steel, and therefore the riveted joint afterwards slips by a greater amount than the steel strains under the same stress. A welded structure is therefore more homogeneous than a riveted one. Further experience would appear to be necessary before saying definitely that, in a combination of riveted and welded joints the greater slip of the riveted joints after the stress exceeds its elastic slip value would throw all the stress on to the welded joints; but in any case such a contingency should be avoided, because it would appear to be unwise to stress a riveted joint beyond its elastic slip value.

With regard to ultimate extensibility and contraction of area of a butt-welded mild-steel piece, these are not as great as in a plain piece of mild steel. This would not appear to be a drawback, because the extensibility of the weld at its breaking point is about sixty times its extensibility at the yield-point, giving a good margin. If, in the future, steel is produced for structural work with higher mechanical qualities than the present mild steel, it follows from what has been said on riveted joints that riveting will not give the extra strength commensurate with the better steel, and welding appears to present the best and probably the only solution. Where electric welding is referred to in this paper, for strength parts, reliable arc welding is meant; spot or resistance welding is dangerous in structural work because an oxide line must of necessity be produced at the junction between the two surfaces, and the unwelded portions act as leading cracks, causing failure through the oxide line.

All that has been stated has been based on the assumption that the welding has been properly carried out. Good welding is essential and depends on the use of an efficient electrode and a capable and conscientious welder. The first of these conditions can easily be met by specification and test. Lloyd's Register, and it is believed the British Admiralty, have already framed tests which would satisfy them. Makers who specialise in the manufacture of electrodes could be depended on to provide suitable material. There is, perhaps, a tendency to-day to use what might be described as "home-made" and imitative electrodes, which are often quite unreliable, even bare-wire electrodes are sometimes suggested. An efficient electrode, amongst other things, should clean the surface of the adjacent metal, prevent oxidisation of the deposited metal, and be easy to control.

The second condition introduces the question of the "human element." Without doubt the welders should have received specialised training, and should prove themselves not only capable of doing satisfactory work, but should be morally incapable of doing scamped work or covering up bad work. But even this matter should be looked at from a broad point of view. Such qualifications are not entirely confined to electric welding, although in this, a comparatively new process, it is only right that careful attention should be given to the matter.

At the present time it is necessary to depend on the skill and integrity of workmen in almost every trade, as it is practically impossible to supervise every part of a process or check every measurement, but naturally the most trustworthy men are placed on the more important and higher technical work. This would be the case with electric welding, where applied to structural work. Reference need only be made to the work of the forge-master in building up large forgings, and the smelter, the moulder, and founder, or the blacksmith on ordinary welding work, to appreciate how fully the individual worker must be trusted. This applies equally well to the accuracy associated with the arts of the patternmaker, the joiner, and all the numerous precision workers in wood or metal. It will undoubtedly be the considered judgment of those with experience in electric welding that only the usual amount of supervision would be necessary to maintain in welding, as applied to structural work, the same character for high-class and reliable work which has generally been associated with the name of the British workman. If an attempt is made to cheapen welding at the cost of efficiency, the future of the industry is imperilled and its development will be retarded for many years.

It is fully realised that all-welded structures will not come suddenly, and for this reason no attempt has been made here to produce, for example, a complete design of such an all-welded ship. Progress must be steady and, it is thought, along the lines indicated herein. It is now recognised by many practical shipbuilders that there are great possibilities in electric welding, and it is to such gentlemen that the author is indebted for some suggestions contained in this paper. At all events, it is hoped that this paper will direct attention to the matter, which need by no means be confined to shipbuilding structures.

The author wishes to express his thanks to Mr. S. J. Wavish, O.B.E., M.Inst.N.A., late shipbuilding manager at Cammell Laird and Co., Limited, Birkenhead, for valuable suggestions and help in the preparation of this paper.

ACTIVATED SLUDGE SEWAGE DISPOSAL PLANT.

*Aeration Units and Sedimentation Tanks for the Activated Sludge Sewage Disposal Plant at Milwaukee, Wisconsin.**

By Darwin W. Townsend, Assoc.M.Am.Soc.C.E.

(*Concluded from page* 214.)

By-Pass Conduit.—The by-pass conduit which begins at the terminus of the riser shaft of the intercepting sewer in the coarse screen house, is to be constructed directly beneath the main sewage conduit and will extend throughout the length of the plant, affording by-pass facilities for the coarse screen house, grit chamber and fine screens. It will also connect with the two effluent channels at a point beneath the mixing channel at the gate-house.

The maximum loss of head in the effluent channels and pressure conduits will occur when all the sewage is by-passed around all the aeration units and sedimentation tanks (a condition which it is hoped will never exist), but as the loss of head due to this condition would occur at the time when the plant would be out of service, the head losses here considered and adopted are those resulting from the determinations based on the maximum discharge of effluent from the sedimentation tanks. Sedimentation tanks Nos. 1, 2, 3, 4 and 5, at the western end of the plant, were assumed to be out of service in making the determination for loss of head.

Return Sludge Channels.—The head loss in the two return sludge channels is entirely separate and apart from the losses which affect the flow through the plant, and was given separate consideration from the standpoint of conserving the head and thus reducing the lift for the return sludge pumps. Each sedimentation tank is equipped with two adjustable discharge pipes, 14 in. in diameter. The double discharge feature affords facilities for discharging the sludge into either of the channels. It is not planned to operate both discharge pipes at the same time, but the design does contemplate the use of both channels at all times, except when it might become necessary to replace a broken filtros plate, repair a pipe, or perform other work of a similar nature in one or the other of the channels. The assumed condition producing the maximum loss of head will occur when one of the channels is out of service and sludge is being withdrawn from each tank at double the normal rate, and the total quantity is being carried in one channel.

The aerated return sludge channels terminate at the gate-house, and the sludge carried by them is discharged at this point into an unaerated forebay located at the entrance to an unaerated pressure conduit. This conduit (54 in. in diameter) is proportioned so that the expected minimum flow of sludge through it will create a velocity somewhat in excess of 2 ft. per second for the 1930 quantity. The flow conditions on which the head losses are based are the same as those described for the channels.

The return sludge pumping equipment will consist of three motor-operated centrifugal pumps, each capable of pumping sludge at rates of 6,000,000 gallons, 9,000,000 gallons and 12,000,000 gallons per day. It will draw its supply from the suction well mentioned previously and force it through a 48-in. cast-iron pipe equipped with a Venturi meter to the head of the fine screen tail channel (mixing channel), where it will be discharged through multiple outlets into the sewage entering the plant. The sludge to be pressed, or waste sludge as it is called, will be taken from the 48-in. force main, or directly from the aeration or sedimentation tanks which may be reserved for the special treatment of waste sludge, and conveyed through a conduit to the sludge de-watering plant.

Sludge Draw-Off Pipes.—Sludge is to be drawn from the sedimentation tanks by means of hydrostatic head and, unless the actual operation of the plant for a period of time shows indications to the contrary, it will be withdrawn at practically a constant rate throughout each 24 hours. Although the designs are based on a constant sludge return of 20 per cent. and facilities are provided at the same time in the sludge draw-off pipes and in the sludge pumping equipment for a variable rate of sludge return, it should not be inferred that a variable rate of return is contemplated.

The basic figure of 20 per cent. and the quantity of sludge corresponding thereto are used in the sense that they represent a probable high average rate, possibly close to the rate which, in actual operation of the plant, may prove to be the maximum required. Seasonal changes, as applied to the character of the sewage, may indicate the necessity for varying somewhat the rate and percentage of sludge return and, in the light of past experience, in connection with the operation of the testing station plant, the indications appear to be that the basic figure of 20 per cent., if varied at all, will be reduced rather than increased.

The facts leading up and entering into the determination of necessary provisions relative to adequate and proper flexibility for devices and apparatus used in connection with the manipulation of return sludge, can be summed up, as follows: First, approximately seven years will elapse between the time of placing the plant in operation and the 1930 period for which it is designed. Second, how closely the actual sewage flow in 1930 will correspond to that which has been estimated, is problematical. Third, the actual rate or rates of returning sludge can be determined definitely for the sewage flow from the entire city only after the plant has been placed in operation. Fourth, there may be occasions, possibly periods of short duration, when sludge will have to be drawn from the tanks at excessive rates. This may be required in order to lower the sludge level in one or more, or possibly all, of the tanks. The likelihood of this condition arising would appear to depend largely on the efficiency of the operation resulting from the personal equation.

The draw-off pipes are 16 in. in diameter on the horizontal, and 14 in. on the vertical run, except those for the 43 ft. tanks which are 8 in. in diameter, horizontally and vertically. There is a cone-shaped entrance to the 16-in. pipes in the bottom of each tank, at the centre, where the sludge which has been deposited on the bottom and which has been brought to the centre by the spiral ploughing action of the Dorr thickeners, enters the draw-off pipes and is carried to the return sludge channels by hydrostatic pressure.

The quantity of sludge being withdrawn is controlled by the difference in head between the elevation of the sewage surface in the tanks and that of the ends of the adjustable 14-in. discharge pipes which are to be operated from floor stands through the medium of worms and circular racks. In selecting the proper size for the draw-off pipes, the determining factors were the minimum velocity and the maximum loss of head, the minimum velocity being established at 2 ft. per second and the maximum loss of head at 3½ ft. An allowance of 1 ft. was made between the centres of the discharge pipes and the maximum elevation of the sludge surface in the return sludge channels, the total distance from the liquid level in the sedimentation tanks to the maximum liquid level in the sludge channels being established as 4½ ft. This allowance will permit unobstructed visual inspection of the flow of sludge from the discharge pipes, and the depth of sludge in the sludge channels, namely, 5½ ft., referred to previously, is sufficient to submerge properly the entrance to the sludge conduit in the forebay, at the western end of the channels.

If all the sedimentation tanks are placed in service during the early years of the plant's operation, the indications are that velocities slightly less than 2 ft. per second will obtain in the 16-in. pipes. If, on the other hand, as a matter of operation, the number of tanks in use for a given flow is proportional to the flow, based on the practical limit of the tank's capacity, it would appear reasonable to assume that the pipe velocities would be susceptible to the same range of control which would obtain when all the tanks are in service and operating on the flow for which the plant as a whole is designed.

The 16-in. pipes are to be cast in the concrete forming the floors of the sedimentation tank and are sufficiently large to accommodate the maximum assumed rates of sludge flow based on sedimentation rates considerably in excess of 1,600 gallons per square foot, without causing the frictional losses to exceed the fixed limit. The 14 in. vertical pipes and adjustable discharge pipes which can be erected independent of the tanks and walls, in combination with the horizontal 16-in. pipes, will accommodate rates of sludge flow corresponding to sedimentation rates to and including 1,600 gallons per square foot, without exceeding the allowable friction loss. Should future requirements so demand, the 14-in. pipes can be removed and a larger size substituted.

The waste sludge has been referred to only casually, for the reason that it is not in sufficient quantity to influence the conditions of flow through the plant. For example, if the daily accumulation of sludge in the plant is at the rate of 15,000 gallons of 98·5 per cent. moisture material per 1,000,000 gallons of sewage treated, the total daily quantity for the 1930 period will be about 1,275,000 gallons and for the 1950 period about 1,920,000 gallons. It can be readily seen that this comparatively small quantity, when distributed over the entire plant, would have no appreciable effect on any calculations pertaining to the plant hydraulics.

Air-Distribution System.—The compressor plant for furnishing air will consist of four, 30,000 cub. ft. per minute, Ingersoll-Rand turbo-blowers direct connected to Allis Chalmers steam turbines. There will be three active units and one spare. Each blower will take its supply of air from the outside atmosphere through screened louvres along the east side of the power-house and just below the roof. The air will pass downward to the blowers through 36-in. cast-iron inlet pipes, equipped with Venturi meters and spray washers for measuring and washing the volume of free air to be compressed. After being compressed, the air will be discharged through 30-in. cast-iron outlet pipes and enter the main air-header leading to the plant. The capacity of each unit should be interpreted as meaning 30,000 cub. ft. of free air per minute compressed to 10 lb. per square inch. The air requirements for the 1930 plant are based on supplying air to the aeration tanks at the rate of 1½ cub. ft. of air per gallon of sewage treated. The conversion of this figure to a single diffuser-plate basis, assuming that sewage is being treated at the rate of 15,000,000 gallons per acre per day, with a diffuser ratio of 1 to 4, results in a figure which indicates that each diffuser plate will pass air at the rate of 1·48 cub. ft. per minute.

Each aeration unit will actually contain 2,514 diffuser plates, and if each plate is supplied with air at the rate mentioned, the total air required per minute per aeration unit will be about 3,820 cub. ft. and, for the 24 units about 90,680 cub. ft. Air will be supplied for agitation to the diffuser plates in all the aerated channels, at the approximate rate of 1 cub. ft. of air per diffuser plate per minute. The total number of plates in the channels is 11,520 and they will require about 11,520 cub. ft. of air per minute. The total quantity of air required for the aeration tanks and channels will be at the approximate rate of 103,200 cub. ft. per minute. It will be noted that this quantity exceeds the combined rated capacity of the three active blowers which is 90,000 cub. ft. per minute at a pressure of 10 lb. The secondary rating of the blowers, which is approximately 35,000 cub. ft. of air per minute at a pressure of 8 lb., indicates an available combined capacity of 105,000 cub. ft. per minute for the three units. This capacity is more than ample to satisfy

* Abstract of a paper presented to the American Society of Civil Engineers.

the air requirements for the plant, and it is questionable whether the pressure losses in the air distribution system as a whole will ever exceed 8 lb. per square inch.

Experience in operating the plant at the testing station has shown conclusively that when foreign substances, such as dirt and oil, are eliminated from the air supply, there is little danger to be anticipated from the clogging of diffuser plates and the resulting increase in pressure.

The equipment which has been selected and purchased for compressing and washing the air, was designed and constructed under specifications which required a 100 per cent. performance relative to the quality of air delivered. The importance of a constant clean air supply is vital to the operation and maintenance of an activated sludge plant and should not be under-estimated.

General Arrangement of Air Piping.—One of the first steps in the design was to give separate consideration to the depths of liquor in the aeration units and in the channels. The depth of liquor in the aeration units, as noted previously, is 15 ft.; that in the feed and mixed liquor channels is 10 ft.; and that in the return sludge channels is about 5½ ft. maximum. The largest proportion of the total quantity of air is used in the aeration units. It is here, also, that the maximum pressure is required, owing to the depth of the liquor.

It was decided, therefore, after having compared the cost of providing and operating separate low-pressure blowers for supplying air to the channels with the cost of supplying air at an excessive pressure from the large units, that better economy could be obtained through the use of a system of sub-headers carrying pressure suitable to the depth of liquor, the supply of air being taken from the main air headers and the reduction in pressure obtained through resistance in pressure-reducing valves. The two sub-headers which supply the feed and mixed liquor channels with air, are connected to the two main air headers at points about opposite the centre of the middle units of the 1950 plant, the connection pipes, which are 12 in. in diameter, being equipped with pressure-reducing valves and air meters. The sub-header supplying air to the return sludge channels and the mixing channel is connected to the main air header at the western end of the plant, in the gate-house. This connection, which is 8 in. in diameter, is also equipped with a pressure-reducing valve and an air meter. Each aeration unit will take its supply of air directly from the main air-header, the connection being made at the top of the header in order to avoid carrying condensate into the piping of the aeration unit. The connecting pipes between the main air-headers and the piping in the aeration units are 12 in. in diameter and each pipe is equipped with a gate-valve and an air meter.

Determining the Air-Pipe Sizes.—Research work carried on in connection with securing data and information pertinent to the allowance of adequate pipe capacity for the air, led to the adoption of the "Thorkelson" formula. This formula may be expressed as follows:

$$P = \frac{L\,V^2}{25{,}100\,B}$$

in which

P = loss of pressure, in ounces per square inch.
L = length of pipe, in feet.
V = velocity of air, in feet per second.
B = diameter of pipe in inches.
25,000 = constant.

Twelve diameters of pipe are allowed for bends of 90 deg.

The allowable pressure drop of 8 oz., which was used as a basis in proportioning the pipe sizes, was determined from cost comparisons (Table II) prepared to indicate the probable relation between the cost of compressing air and that of enlarging the pipe sizes to reduce friction losses.

Although the comparative values, shown in column (5), of Table II, would not be the same as those which would result from actual cost analyses of various air-pipe combinations, corresponding to the pressure differences shown in column (1), the general tendency of the annual charges to decrease as the friction losses are decreased, would appear to hold strictly true.

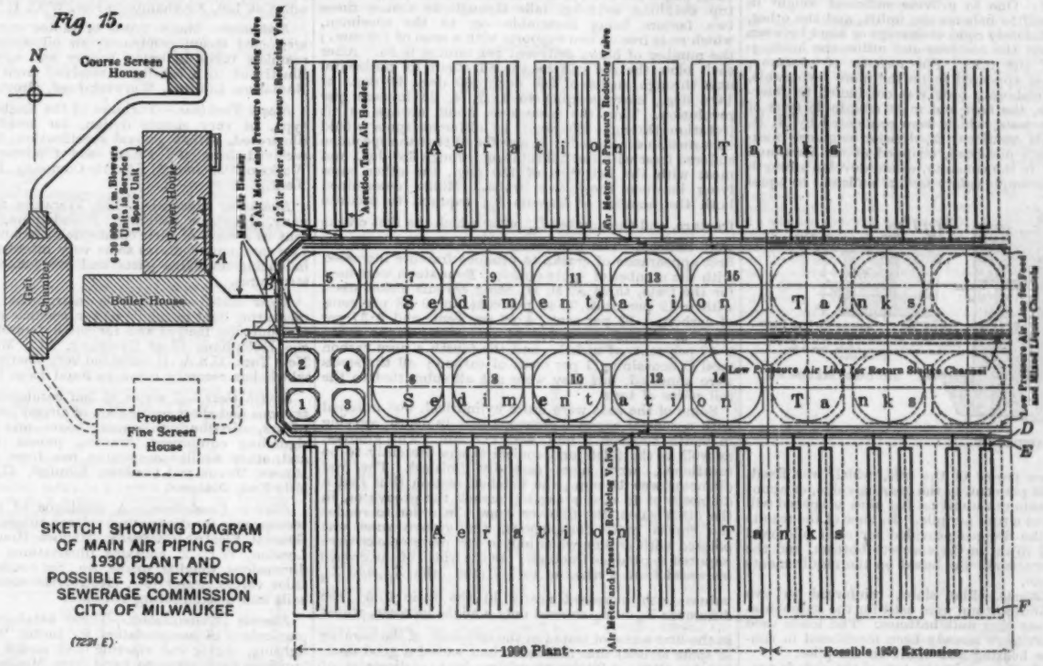
In consideration of the foregoing indications relative to the economical necessity for maintaining friction losses in the air mains at a practical minimum, a careful study of all the conditions entering into and affecting the actual installation of an air-pipe system was made, with the result that the combination of sizes finally adopted appeared to suit best the conditions. The friction losses were calculated along the line A B C D E, on Fig. 15, which is a diagram of the main air-piping for the 1930 plant and possible 1950 extension. Point A is in the power-house; point B at the junction of the 66-in. and 60-in. pipes in the gallery, just north of the centre of the plant; point C at the south-west corner of the south gallery; point D at the extreme end of main air-header in the south gallery; and point E at the top surface of the most remote diffuser plate in the far end of the most easterly aeration tank in the 1950 plant. The total loss due to friction along this line is approximately 0·5 lb.; making a total loss of approximately 1·55 lb., based on the estimated requirements for the 1950 plant.

The approximate pressure under which the blowers will possibly operate in 1950 is 8·06 lb. per square inch. This figure is obtained by adding the pressure due to the 15-ft. depth of liquor in an aeration unit to the sum of the friction losses. It can be readily seen that the blower pressure for the 1930 plant will be somewhat less than 8·06 lb., possibly about 7·75 lb. The pressure of the air supplied to the channel piping, as stated previously, will be proportioned, except for the small friction losses, to the depth of liquor in the channels. In all cases these pressures will be considerably less than those in the aeration units.

Character of Pipe Required.—Cast-iron pipe, class A bell and spigot, was adopted for the main air-headers and for the headers in the aeration units. It was selected on account of its lasting qualities, rigidity, resistance to corrosion, and the ability of the lead joints to allow movement due to expansion and contraction. Rigidity is referred to as an important factor with special reference to the larger sizes—from 36 in. to 66 in.—as compared with equal sizes of made-up commercial pipe of less substantial construction. All cast-iron pipe is to be well-coated inside and out, with asphaltum paint. All the sub-air headers and the small piping in the channels and aeration units are to be of galvanised wrought iron pipe. All the fittings are likewise to be galvanised.

Diffuser Plates.—The diffuser plates to be used are a kiln-burned silica product and are known by the trade name of "filtros" plates. These plates, which are 12 in. square and 1½ in. thick, are hard and porous, and will not disintegrate or show signs of deterioration when they are immersed in sewage and subjected to the chemical actions taking place therein.

Fig. 15.



SKETCH SHOWING DIAGRAM OF MAIN AIR PIPING FOR 1930 PLANT AND POSSIBLE 1950 EXTENSION SEWERAGE COMMISSION CITY OF MILWAUKEE

(7221 E)

The specifications under which the filtros plates are being manufactured for the Sewerage Commission of Milwaukee provide that each plate, when dry, shall pass air at the rate of from 8·9 cub. ft. to 12·9 cub. ft. per minute under a 2-in. water pressure. The plates are to be placed in pre-cast concrete containers. The setting of the containers and making the air-pipe connections thereto will not be done until the construction of the aeration units and channels is practically completed.

Notes and Data.—The conditions influencing and controlling the design of the structure for the disposal plant at Milwaukee do not differ, to any great extent, from those which have been encountered and studied elsewhere, and, although certain features of the design are based on data and analyses of conditions, probably not heretofore generally used, the design as a whole possesses no unusual features.

The shape and size of the tract for the sewage disposal works were determined in conjunction with the development of plans for the proposed harbour improvements. The decision arrived at relative to the arrangement of the disposal works as a whole was that the necessary structures for the cage screens, rack screens, fine screens, grit chambers, blowers, generators, boilers, presses and dryers, should be located on the fast land of the tracts, and that the aeration units and sedimentation tanks should be constructed on a site to be prepared in Lake Michigan adjacent to the fast land. In accordance with this decision, a large coffer-dam was designed and constructed, and the enclosed area which is approximately 700 ft. by 900 ft., after having been dredged hydraulically to about elevation — 12·50, was dewatered.

The fact that all the structures would have to be placed on pile foundations was recognised from the beginning, and a series of tests was undertaken to determine the fixed loss allowed for resistance through diffuser plates is 0·75 lb., which is simply safe, and the fixed losses occurring at the blowers are approximately 0·3 lb.,

TABLE II.—*Relative Costs, Based on the Air Requirements for the 1950 Plant.*

Pressure.	Annual Cost of Compressing 150,000 Cub. Ft. of Free Air per Minute.	Cost of Air Mains.		Annual Charges.
	Percentage of Cost.	Percentage of Cost.	Interest Percentage on Cost at 6 per Cent.	Percentage of Cost of Compressing Air, plus Interest on Pipe Installation.
(1)	(2)	(3)	(4)	(5)
lb. oz.				
7 4	90+	174—	174—	93—
7 5	91+	168+	168—	93+
7 6	91+	161+	161+	94+
7 7	92+	156+	155+	95—
7 8	93+	149+	149+	95+
7 9	94+	143—	143—	96—
7 10	95—	137—	137—	96+
7 11	96—	131—	131—	97+
7 12	97—	125+	125—	98—
7 13	97+	118+	118+	98+
7 14	98—	112+	112+	99—
7 15	99+	107+	107+	99+
8 00	100	100	100	100

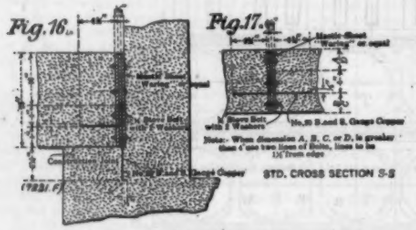
allowable bearing for the piles. An allowance of 16 tons per pile was decided on.

Conditions of Loading on Piles.—The condition of loading on which the spacing of piles was determined, took into account the total dead weight of the tanks and channels, and also the weight of the sewage contained in them when filled. The piles under the sedimentation tank bottoms are spaced 5 ft., centre to centre, both ways, and those under the aeration unit bottoms were spaced 5 ft. 6 in. in one direction and 4 ft. 7 in. in the other. In each case, the loading requires one pile for approximately each 25 sq. ft. of area, except under the walls where closer spacing is needed.

If the level of the water in Lake Michigan is elevation 0·00, the uplifting force acting on the bottoms of the sedimentation tanks will be that due to a hydrostatic head of 13 ft., or about 812 lb. per square foot, and that acting on the bottoms of the aeration units will be about 740 lb. per square foot, or that corresponding to a hydrostatic head of 11·83 ft.

This uplifting force, of course, will be more than balanced by the weight of the tanks and channels which will be filled with sewage when the tanks are in service, and partly balanced by the weight of the structures alone when empty. It is the latter condition which must be met to insure the stability of the plant against conditions likely to be met in operation, which would require the emptying of the units.

Two methods of satisfying this condition were carefully considered: One to provide sufficient weight in the structure itself to balance the uplift, and the other, to provide a sufficiently rigid anchorage or bond between the pile-heads and the concrete and utilise the holding-down power of the piles. For reasons of economy, the latter method appeared to be the more favourable, and a series of elaborate tests was conducted to determine, if possible, the best and most adaptable type of anchorage. The tests, which were conducted by R. R. Lundahl, Assoc.M.Am.Soc.C.E., division engineer, indicated that a plain pile-head, stripped of the bark and embedded 10 in. in the concrete, would develop strength in bond, with an ample safety factor, sufficient to equal



the holding-down power of the pile, which was fixed, with safety, at 50 per cent. of the bearing value, or about 8 tons. The maximum uplift on the piles as spaced will not greatly exceed 6 tons per pile. In view of the results of these tests, the designs provided for each pile-head to be embedded 10 in. in the concrete bottom, and the weight of the structures was based on the requirements for strength alone.

Design of Bottoms.—Flat slabs, reinforced in two directions, top and bottom, were used for the sedimentation tank and aeration unit bottoms. The loads used were those which have already been mentioned in connection with the bearing and uplift on the piles.

The steel reinforcement in the top of the slab is proportioned to the moment resulting from the hydrostatic uplift, and the negative moment over the supporting piles is due to the force of the downward loads. The steel in the bottom of the slab is proportioned to the downward loads acting independently of the uplift.

Design of Walls.—Main walls of the cantilever type, reinforced on both sides. These were designed with 0·003 of steel, and this type is used for the aeration units sedimentation tanks and channels. Walls subject to the same water pressure on both sides were proportioned and reinforced to withstand the total load from either side. Walls subject to a combined earth and water load on one side and a water load on the other side, were treated in a similar manner. The loading referred to as combined earth and water is that due to back-fill in contact with outside walls and to the hydrostatic condition of the back-fill which is assumed to be completely saturated below zero elevation. The horizontal unit pressure exerted by the saturated back-fill is assumed to be about 100 lb. per square foot for each foot of depth. The tension allowed in the steel throughout the design was 16,000 lb. per square inch, and the maximum compression allowed in the concrete was 650 lb. per square inch.

Expansion Joints.—Expansion joints of the general type shown as sections T-T and S-S, in Figs. 16 and 17, were incorporated in the design. Where used, these joints completely separate the adjacent parts of the structure. Each entire section of the plant between the expansion joints is securely tied together with reinforcing rods and, from a structural standpoint, is a self-contained unit. The copper sheet is to be stitch-riveted and soldered at joints, corners and intersections, in order to secure water-tightness.

Galleries.—The operating galleries will be constructed of brick, with reinforced concrete and composition roofing and steel roof beams.

General.—The "thickeners" or concentrators, with which all of the sedimentation tanks are to be equipped, will be supported from steel trusses spanning the tanks. The reduction gearing, motors, &c., for driving the apparatus, will be mounted on the top chords of the trusses and will be protected from the elements by housings of hy-rib construction. A 4-ft. water main carrying city pressure is provided for each of the three galleries. These mains, which will be suspended from the roof beams, are to be fitted with drop pipes and hose connections 2½ in. in diameter, opposite each sedimentation tank and each aeration-tank battery, for the purpose of providing facilities for flushing the tanks, channels and drains.

Conclusion.—The work has been directed and developed under the direction of T. Chalkley Hatton, M.Am.Soc.C.E., chief engineer of the Sewerage Commission, and for several years past, Harrison P. Eddy, M.Am.Soc.C.E., has been employed for the Commission in the capacity of consulting engineer.

IMPACT ENDURANCE TESTS OF RODS OF VARYING CROSS-SECTION.

THE endurance tests, to which Dr. Ing. W. Müller and H. Leber, of the Materialprüfungsamt at Darmstadt, have been submitting rods of varying cross-section, bring out some features which, though not altogether novel, make one regret that their Krupp machine did not admit of varying the experimental conditions to a larger extent. (*Zeitschrift Verein Deutscher Ingenieure*, 1921, pages 1089 to 1094.) In the machine referred to a tup weighing 4·18 kg. falls through 30 mm.—these two factors being invariable—on to the specimen, which rests free on two supports with a span of 100 mm.; the number of blows delivered per minute is 86. After each blow the rod can be turned about its horizontal axis through angles of 360 deg., 180 deg., 90 deg., or 14·4 deg., corresponding to 1, 2, 4, 25 impacts per revolution. Thus the same spot would always be hit (rotation through 360 deg.), or different spots would be struck in succession. It was found that the specimen suffered least with the full rotation through 360 deg., and most with the half-turn of 180 deg., the other cases lying between these two limits. Müller determined both the number of impacts Z_B, required to produce fracture, and the number Z_R, after which the first cracks were noticed. The number of blows required after the first appearance of cracks to produce fracture increased with the number of spots struck. Four steels were used for the tests, three A, B, D, being chrome-nickel steels with 0·12 per cent., 0·40 per cent., or 0·13 per cent. of carbon, 4·93 per cent., 4·52 per cent. and 3·37 per cent. of chromium, and 0·94 per cent., 1 per cent., 0·57 per cent. of nickel; and the fourth a pure carbon steel C containing 1 per cent. of carbon; all the steels were annealed, but they were not all submitted to the full series of tests.

Some of the rods were quite cylindrical, but notched with a central rounded groove, 1 mm. in depth, varying in width between 2 mm. and 7·7 mm. The grooves, as well as the fillets and conical tapers presently to be mentioned, were most carefully finished. The rod diameter was 15 mm., the notched section thus had a diameter of 13 mm.; the tup struck the groove or, in the other cases, the fillet or cone. In order to render the cracks more conspicuous, the groove zone was painted with aniline when only a few more cracks were required to produce fracture. As the width of the groove increased from 2 mm. up to 7·7 mm., the Z_B and Z_R values both increased nearly in the ratio 1 : 5; the difference $Z_B - Z_R$ showed only a slight increase, whilst in the first series of tests (on the influence of the number of spots struck) that difference had varied a good deal. In the other rods the transition from a diameter of 13 mm. to one of 17 mm. was made either by a fillet or a cone. The fillet radius was varied between 0 mm. and 7 mm. As the radius increased, the Z_B and Z_R again increased, the curve being first a straight line up to a fillet of 4 mm. and then bending over; there was hardly any further rise between 5 mm. and 7 mm., but the increase was again very marked, whilst the difference $Z_B - Z_R$ remained almost constant. Cracks formed first in the zone where the cross-sections began to increase; but quite shallow tool marks, not extending all round the rod, did not seem to influence the formation and direction of cracks. The length o the conical tapers varied in the different specimens between 0 mm. and 4 mm.; this length did not appear to have any influence on the Z_B and Z_R values, which were all smaller than in the fillet tests; these tests were made with the D steel whilst the C steel had been used in the fillet tests; the former was of lower impact strength than the latter. Finally some specimens were stressed in the machine until cracks developed; the surface layer was then turned off on the lathe, and the rod, now of reduced cross-section, in which the microscope could no longer discern any cracks, was submitted to further stress; the rod showed an increased strength. Thus it would appear advisable from these tests, in accordance with others, that the surfaces of shafts should be most carefully finished, especially at spots where a change in cross-section occurs, and that fillets should be of large radius and are probably preferable to conical tapers.

THE CHRISTIANIA STEEL WORKS.—These works, which have recently failed, were started in 1886. The share capital was 12,000,000 kr. This is unfortunately lost, together with an additional 3,000,000 kr. It was intended in 1917 to put down a large rolling mill, and a State guaranteed loan of 6,500,000 kr., besides an annual subsidy for the first five years, were confidentially reckoned upon, but failed to materialise.

CATALOGUES.

Shears.—Messrs. Henry Pels and Co., 1, Boymans-straat, Rotterdam, send a catalogue of several types of powerful shears for cutting up scrap. All are made with steel plate frames.

Electric Cables.—A pamphlet describing the Bowden-Thompson system of protecting electric cables is to hand from the Macintosh Cable Company, Limited, Rice-lane, Walton, Liverpool.

Electric Lighting.—A copy of the seventh edition of their useful one shilling booklet on electric lighting connections has reached us from Messrs. A. P. Lundberg and Sons, 477, Liverpool-road, London, N. 7.

Lubrication.—Some useful matter relating to the lubrication of machinery is given in a pamphlet entitled "Germ Process Motoils," issued by the Henry Wells Oil Company, 11, Haymarket, London, S.W. 1.

Transformers.—A second series of notes or "abstracts" explaining the technical information required for drafting inquiries and tenders for electric transformers has been issued by Messrs. Johnson and Phillips, Limited, Charlton, London, S.E. 7.

Air Compressors.—The De Laval Steam Turbine Company send a catalogue of blowers and compressors to be driven by steam turbine electric motors or by belt. The company's works are at Stockholm, and the London office at 150, Southampton-row, W.C. 1.

Radiators.—Many types of motor car radiators, an air-cooled steam condenser, an oil cooler, and drawn seamless tubes in brass, copper and nickel silver, are illustrated in a catalogue received from Messrs. Serck Radiators, Limited, Warwick-road, Greet, Birmingham.

Steam Turbines.—Turbines of the single-stage impulse type, of very simple design, for small outputs, are illustrated, with a general specification, in a catalogue received from the Fraser and Chalmers Engineering Works of the General Electric Company, Limited, Erith, Kent.

Balancing Machines.—The Vibration Specialty Company, Harrison Building, Philadelphia, U.S.A., have sent us a copy of their catalogue of balancing machines. The catalogue contains some very interesting matter on balancing revolving parts and overcoming vibration in structures.

Light Meter.—A portable instrument for accurately measuring light in candle power, coefficients of reflection, transmission factors and for colour matching, made by the Holophane Glass Company, 342, Madison-avenue, New York, U.S.A., is described very clearly in a catalogue which has recently come to hand from that company.

Switch Gear.—A series of leaf catalogues giving illustrations and short particulars of circuit breakers, control pillars, distribution boards, boxes and pillars, fuses, signalling equipment, starting panels, switch boards and other similar apparatus has been received from Messrs. Mavor and Coulson, Limited, 47, Broad-street, Mile End, Glasgow.

Electric Condensers.—A catalogue of condenser protective gear for dissipating voltage surges, issued by the General Electric Company, Magnet House, Kingsway, London, W.C. 2, contains illustrations and tables of dimensions, weights, prices, &c., for condenser batteries, Giles valves, water jets, electrolytic arresters, choking coils and disconnecting switches.

Electric Accumulators.—Three catalogues containing particulars of accumulators for motor 'bus and coach lighting, motor car starting and motor car and boat ignition, have come to hand from Messrs. Oldham and Son, Limited, Denton, Manchester. Each catalogue contains tables of dimensions, capacities and prices for a full range of general requirements.

File Dressing.—A machine for cleaning and sharpening files is described in an advance catalogue received from Messrs. Ronald Trist and Co., Limited, 12, Slipstone-street, London, W. 1. The files are gripped mechanically and subjected to the action of a jet of water and abrasive material, the water pressures employed being about 60 lb. per square inch for cleaning and 120 lb. per square inch for re-cutting.

Portable Conveyors.—Various types of portable conveyors which may be easily applied and shifted from place to place in the work of excavating, building and loading materials from ground heaps into vehicles are illustrated and described in a catalogue issued by the Ritchie-Atlas Engineering Company, Temple, Glasgow. The machines may be suspended or mounted on castors or large wheels, or on swivelling bases.

Steel.—Two little catalogues from Messrs. Samuel Osborn and Co., Limited, Sheffield, contain many illustrations of their castings and forgings, in manganese steel and in toughened steel. A third catalogue of carbon tool steels contains much useful information about working and heat treatment, with reproductions of the labels used for each kind of steel. The firm make a special steel for the manufacture of snaps, chisels, caulkers, &c., to be used with pneumatic tools.

Gas Producers and Engines.—A very complete description of gas producers and engines appears in a new 28-page catalogue issued by Messrs. Ruston and Hornsby, Limited, Lincoln. The single-cylinder engines are made in a large number of sizes, from 12 b.h.p. to 170 b.h.p.; and the double-cylinder type from 94 b.h.p. to 340 b.h.p. The producers, for anthracite, coke or charcoal are made in corresponding capacities. A list of engines for working on town gas in sizes ranging from 14 b.h.p. to 100 b.h.p. is also given. All the engines are tested to 15 per cent. overload before being sent out.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

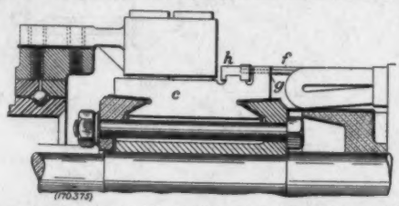
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

170,375. J. Stone and Co., Limited, Deptford, and A. E. Honey, Ilford. Dynamo Electric Machines. (6 *Figs.*) July 16, 1920.—The invention is concerned with improved means for cooling the soldered connections between the armature windings and the commutator bars of dynamo electric machines, and has particular reference to the known commutator bars which have been provided with radiator wings for the purpose stated. According to this invention, radiator fins, blades, paddle-like devices or equivalent heat radiator and air-agitating means A are separately applied to selected commutator bars *c* in close proximity to some or all of the soldered connections *g* of the armature windings *f*, and are connected as by soldering, with the conductors *f*, so as to have a firm and heat-conducting connection therewith. In this way, the fins, blades or paddles A



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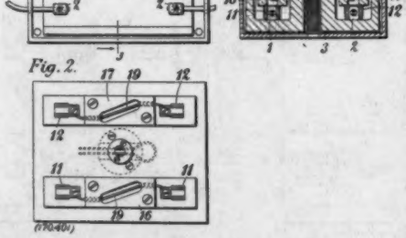
exercise a cooling effect due partly, and perhaps chiefly, to their conductive and radiative capacity, and partly to their wind vane capacity, whereby air currents may be directed on to the soldered connections *g*. The fins, blades or paddles A being mounted on the commutator bars *c* with which the armature windings in question are connected, thereby afford an additional electrical connection between any one of the bars and its appropriate armature windings. If desired the armature conductors *f* may project beyond the places where the soldered connections are made with the commutator bars, so as to provide radiator surfaces, but in this case, radiator fins are also provided, being in firm heat-conducting connection with the armature conductors. (*Sealed.*)

170,401. C. L. J. B. Nadaud, Great Malvern, and F. Young, Rochester. Electric Switches. (3 *Figs.*) July 20, 1920.—This invention refers to a switch fuse, that is a switch having combined with it a fuse. According to the invention, a switch fuse comprises a fixed member 3 carrying a pair or pairs of switch contacts 1, 1, 2, 2; a second member carrying a co-operating pair or pairs of switch contacts 11, 11, 12, 12, and



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adapted to move rectilineally towards or away from the fixed member 3 and fuse carriers 16, 17 on the second member for the connection of a fuse 19 across each pair of contacts 11, 11, and 12, 12. Preferably the switch contacts 1, 1, 2, 2, are situated in a box-shaped member 4, and the switch contacts 11, 11, 12, 12 are mounted on a member such as a plate which slides in the box 4. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

170,344. J. Hanman, Haverstock Hill, London. Sparking Plugs. (8 *Figs.*) July 12, 1920.—This invention relates

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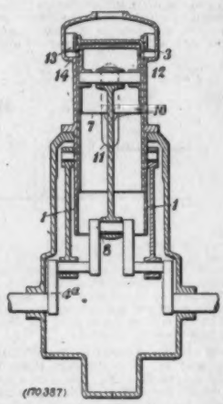
to sparking plugs. The body of the plug terminates in an externally screw-threaded end *a* provided with a smooth internal bore for the reception of a pronged and flanged thimble electrode *b*. The flange *b*1 of the thimble *b* is seated in a recess *a*2 at the top of the bore. Resting on the flange *b*1 is a dished metal washer *c* which receives the lower part of the china insulator *d* that carries the central electrode. Seated on the body of the insulator *d* is a metal washer *d*2. The parts mentioned are firmly held in position by a nut *e* screwed into the upper part of the body of the plug. To withdraw the electrodes, it is only necessary to screw off the nut *e*, whereupon the central electrode *d* and washer *d*2 can be withdrawn, leaving a clear space to enable the lower washer and flanged thimble electrode to be withdrawn. To permit of a quick removal of the plug described from the cylinder, the screwed end *a* is formed with an interrupted thread, to engage in a corresponding interrupted thread in the cylinder, so that a half or other turn, according to the number of lands in the threads, locks or releases the plug. (*Sealed.*)

170,387. J. J. Proffitt, Walsall, S. Llewellen, Walsall, and H. F. Adams, Birmingham. Internal-Combustion Engines. (3 *Figs.*) July 19, 1920.—In internal-combustion engines of the two-stroke type comprising an outer piston 3 working in the cylinder 1 and an inner piston 7 working in the outer piston 3, the inner piston has a longer stroke than the outer piston so that when the outer and inner pistons move outward on the firing stroke the inner piston draws a supply of combustible gas into the space between the pistons by way of ports in the cylinder and outer piston. According to the present improvements, the gas is drawn into the space between the inner and outer pistons 7, 3 throughout a considerable portion of the outward movement of the inner piston 7, whereby it is ensured that an adequate supply of combustible mixture is drawn in from the carburettor. Ports or slots 10, 11 are respectively formed in the cylinder 1 and the piston 3, these ports being so arranged that during the downward movements of the pistons 3, 7 combustible gas is drawn therethrough into the space between the



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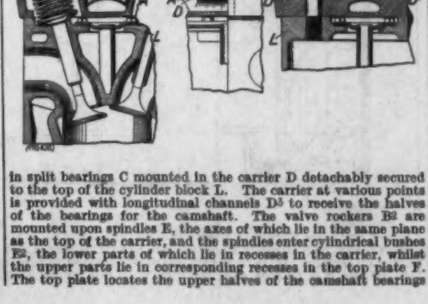
pistons 3,7. The arrangement of the ports 10, 11 is also such that combustible mixture is sucked in substantially through the outward movement of the piston 7. A mushroom valve is mounted in a casing fixed to the side of the cylinder 1 and is mechanically opened and closed for every revolution of the crankshaft. Upon the return movement of the pistons 3, 7, the gas is compressed as the piston 7 moves at twice the rate of the piston 3. Ports 12 are formed in the extension 13 of the cylinder 1, and ports 14 are also formed in the piston 3. When the piston 3 nears the end of its exhaust stroke, the ports 12, 14 register and allow the compressed gas to pass to the head of the cylinder. The exhaust stroke of the piston 3 effects the scavenging, whilst the inrush of compressed gas completes the scavenging action. When the gases are fired, the inner piston 7 is in a position closing the ports 12, 14, and the crank portion 4a is at an angle to the crank portion 8, so that the piston 3 moves in advance of the piston 7 to close the ports 12 to prevent communication between the head of the cylinder 1 and the space between the two pistons. (*Sealed.*)

170,436. Bentley Motors, Limited, London, and W. O. Bentley, London. Internal-Combustion Engines. (3 *Figs.*) August 10, 1920.—This invention relates to internal-combustion engines of the kind in which the camshaft for operating the valves is mounted in a channel formed in a casing arranged over the cylinders and actuates the valves by means of rockers, a removable cover plate being provided to close the channel and to form bearings for the fulcra of the rockers. The cam shaft A operates the valves B through the rockers B2 and the shaft runs



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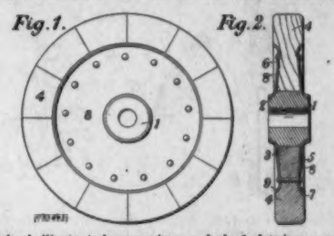
in split bearings C mounted in the carrier D detachably secured to the top of the cylinder block L. The carrier at various points is provided with longitudinal channels D3 to receive the halves of the bearings for the camshaft. The valve rockers B2 are mounted upon spindles E, the axes of which lie in the same plane as the top of the carrier, and the spindles enter cylindrical bushes E2, the lower parts of which lie in recesses in the carrier, whilst the upper parts lie in corresponding recesses in the top plate F. The top plate locates the upper halves of the camshaft bearings by means of dowels, and, when bolted down the camshaft bearings are properly held, and the bushes E2 for the rockers are also secured. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

170,482. F. W. Brampton, Edgbaston, Birmingham. Truck Wheels. (2 *Figs.*) September 28, 1920.—This invention relates to wheels for trucks of the class comprising a hub, a number of blocks of wood arranged around the hub and a pair of side plates clamping the blocks in position and secured by transverse fastenings. A truck wheel of the class described, according to the present invention, has one or both sides of the blocks recessed to receive side plates, the recesses being formed so as to provide shoulders, whilst the side plates are correspondingly shaped, whereby radial displacement of the blocks is prevented by the plates independently of the transverse securing means



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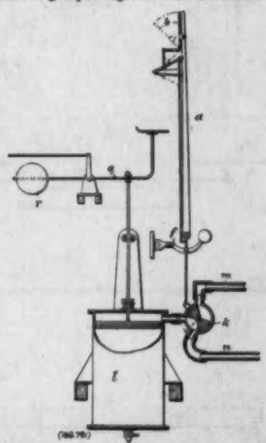
The wheel illustrated comprises a hub 1 having a pair of shoulders 2 and a cylindrical outer surface 3. The blocks 4 are placed around the hub and their inner ends abut against the surface 3. Both sides of the blocks are recessed as shown in Fig. 2, so that the inner ends 5 of the blocks are of dovetail shape in cross-section. The recessing of the blocks in this fashion provides each block with two inclined shoulders 6 and two curved shoulders 7. The side plates 8 are of conical shape, as shown, and their inner ends are forced on to the shoulders 2 of the hub 1, so as to effect driving fits thereon. The outer ends 9 of the plates 8 are outwardly curved corresponding to the shoulders 7 of the blocks 4. (*Accepted* November 2, 1921.)

168,781. F. Pratt, Tynewydd, Treherbert. Winding Engines. (1 *Fig.*) September 10, 1920.—According to the present invention, for automatically applying the footbrake of a winding engine, a fluid pressure cylinder *l* is connected to the counter-weighted pedal lever *g* of the foot brake, and a grip handle *b* is provided on the usual regulator lever *a* that controls the throttle valve of the engine. Fluid pressure is admitted to the cylinder *l* to apply the foot brake unless the grip handle *b* is grasped together with the handle of the regulator lever by the engineman. The arrangement operates as follows: When the grip lever *b* is grasped together with the handle of the regu-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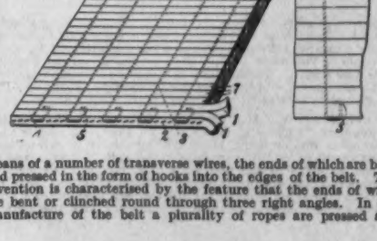
lator lever *a*, the parts are in position shown and the cylinder is open to the exhaust pipe *n*. The foot brake is then off and the piston is held up by the weight *r* of the pedal lever *g*. The brake can as usual be operated by the foot. Should the grasp on the handle of the regulator lever *a* be so relaxed as to release the grip lever *b*, the slotted and weighted lever *f* to which it is connected falls, and the valve *k* to which the grip lever *b* is also connected, is moved to a position in which the cylinder *l* is disconnected from the exhaust pipe *n* and connected with the steam supply pipe *m*. The piston is forced downwards and draws down the pedal lever *g* to apply the brake to the winding drum. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

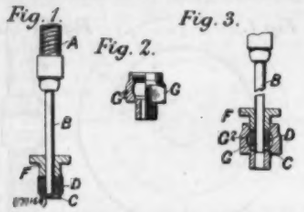
170,340. J. Taylor, Seacombe. Belting. (2 *Figs.*) March 9, 1921.—This invention relates to that class of belting in which a plurality of elements each formed of cords, is laid parallel and adjacent to one another and held together by



means of a number of transverse wires, the ends of which are bent and pressed in the form of hooks into the edges of the belt. The invention is characterised by the feature that the ends of wires are bent or clinched round through three right angles. In the manufacture of the belt a plurality of ropes are pressed and

their flat edges joined by stitching 2. The end of a wire 3 is then passed through one or more of these rope elements 1, and is hammered over at right angles to form a knuckle joint, and finally clinched as shown at 5. A further number of rope elements 7 is then threaded on to the wires 3, and the outer ends 8 of these wires are then bent over at right angles as shown at 9, and the extreme ends 10 are then hammered into the edge of the belt. (*Sealed.*)

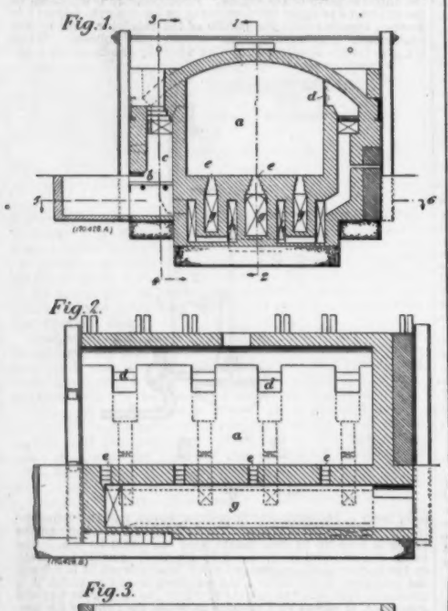
170,164. K. Rotherham, Coventry, and H. N. Smith, Whitley, near Coventry. Lubricators. (11 *Figs.*) August 19, 1920.—This invention relates to means for lubricating bearings of the type in which a grease gun of large capacity is provided with a flexible tube adapted to be connected quickly to a cup on each bearing, so that a number of bearings can be supplied with grease rapidly and efficiently. According to this invention, the flexible tube A terminates in a hollow stem B adapted to



enter the cup G, and this stem carries a piece of rubber tube D, resting upon an abutment C on the end of the stem, and above this is a collar F adapted so to engage the cup as to cause the sleeve to be compressed endwise slightly. The outer wall of the collar F is threaded and is adapted to screw into the mouth of the cup G attached to the part to be lubricated. The cup G is recessed internally at G1. To use the device, the stem B is inserted in the cup and the collar F screwed one or two turns into the cup. When the grease is forced in, it presses the rubber tube D upwards and outwards, causing an efficient seal at the side and at both ends as described. (*Sealed.*)

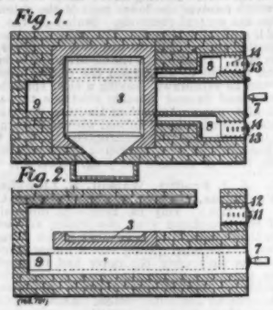
MINING, METALLURGY AND METAL WORKING.

170,428. A. Smallwood, Highgate, London. Furnaces. (5 *Figs.*) July 31, 1920.—This invention comprises a furnace having a working chamber *a* adapted to be heated by a plurality of fire boxes *b*, *c* located around the perimeter thereof. Each of the fire boxes delivers into an uptake *c*, which at its upper extremity is branched laterally and adapted to feed two ports *d* admitting to the working chamber *a*. The



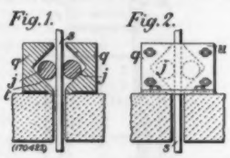
furnace gases egress from the working chamber *a* by a series of ports *e* distributed on the floor, which ports lead to waste gas flues *g* located below the floor and forming part of a recuperator system. The other part of the recuperator system constitutes air flues *h* within which the air is heated by the waste gas flues *g*. The air flues *h* supply heated air to the lateral branches of the uptakes *c*. (*Sealed.*)

168,791. W. H. Boorne, London. Tin-Oxidising Furnaces. (2 *Figs.*) September 23, 1920.—According to this invention, one or more, preferably two, inlet passages 8 for the air to assist in oxidising are built in the walls of the furnace, with inlets adjacent to the fuel burners 7, and are provided with dampers which are preferably of cylindrical slotted form. The air inlet passages 8 communicate through openings 9 with the combustion chamber between the burners and the hearth 3, and preferably at a lower level than the hearth. The draught is controlled by a damper 11 opening into the uptake and formed of a fireclay tube having slots 12 cut in its sides and a closed head.



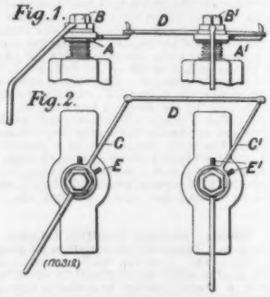
By pulling the damper out, air enters and reduces the draught over the hearth 3. Other dampers 13, of similar construction, and having air inlets 14, control the air entering the air inlet passages 8. (*Sealed.*)

170,422. F. Ringrose, Sheffield, and J. Mac B. Neil, Anniesland, Glasgow. Furnace Flue Dampers. (2 *Figs.*) July 27, 1920.—This invention has reference to furnace flue dampers of the type in which rollers are provided to prevent the passage of gases into and out of the flue through the opening in the wall of same through which the damper slides edgeways. According to this invention, two similar castings *q* are formed in their opposite faces with a "V-shaped groove *t* arranged horizontally



from end to end of the castings. A roller *r* rests upon the lower-angled limb of each groove and bears, with a yielding pressure, against the surface of the damper *s* under the influence of gravity. The two castings are connected together by adjustable end plates *u* which are of angled or kneed formation, and which are secured to the end surfaces of the castings by studs which pass through slots formed in the end plates so that the distance apart of the castings may be adjusted. (*Sealed.*)

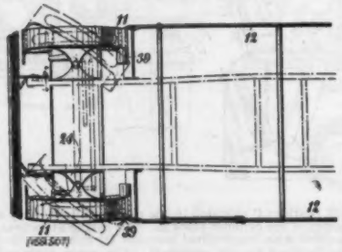
170,312. W. Miles, Aberavon, Port Talbot, W. Thomas, Port Talbot, and W. B. Hallowes, Port Talbot. Rolling Mills. (2 *Figs.*) April 17, 1920.—This invention relates to a pass adjustment device for rolling mills of the type in which the screws or screw pins are simultaneously adjusted by a pair of levers mounted on the screws and connected together by a rod. The present invention consists in the provision of set screws to hold the levers in adjusted relative position on the screws or



screw pins. As shown, the screw pins of a rolling mill are provided with collars A, A1, formed on the interior to fit the hexagon portion of the screw pins B, B1, respectively and machined on the exterior to receive the levers C, C1, respectively. The levers C, C1 are connected by means of a rod D. In accordance with the invention, the collars A, A1 are secured to the levers C, C1 by means of set screws E, E1, which permit the operator to arrange the levers C, C1 in any desired position. (*Sealed.*)

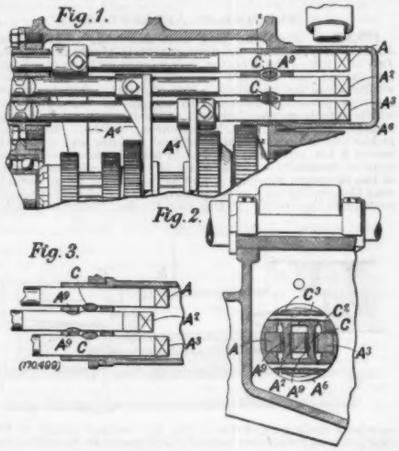
MOTOR ROAD VEHICLES.

169,507. G. J. Shave, Westminster, London, and The London General Omnibus Company, Limited, Westminster, London. Life-Guards. (8 *Figs.*) June 25, 1920.—



According to one feature of the invention, a life-guard 11 of the wheel cage type is pivotally mounted upon a part 24 of the vehicle borne by springs. By carrying the guard upon a sprung part of the vehicle, it is relieved from the vibrations and jars which it would receive were it mounted directly upon the wheel or wheel axle. The life-guards are connected to and operated by a part which moves with the steering mechanism. According to another feature of the invention, the peripheral portions of the wheel cage are extended, as at 39, sufficiently inwardly towards the longitudinal centre line of the vehicle as substantially to close the space between the wheel cage and an adjacent life-guard 12 in all positions to which the wheel cage will be required to move. (*Sealed.*)

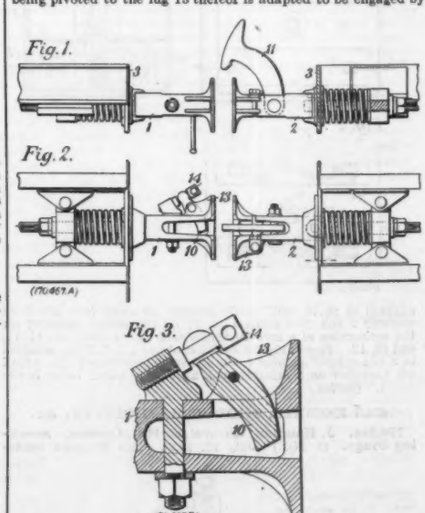
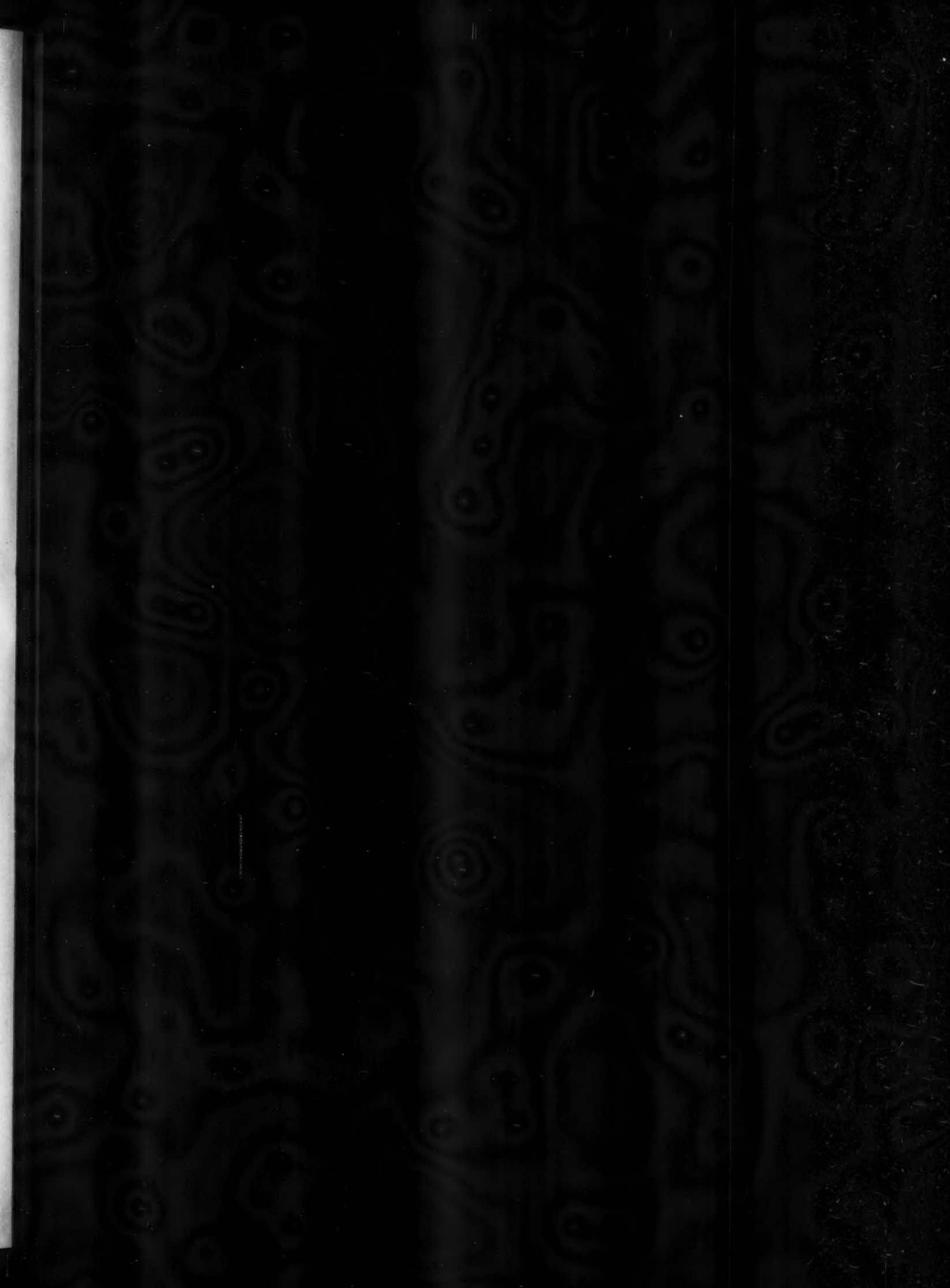
170,499. Bamford and Martin, Limited, Kensington, London, J. A. O. Addis, Kensington, London, L. Martin, Kensington, London, and J. W. Smith, Coventry. Change-Speed Gearing. (3 *Figs.*) November 10, 1920.—In change-speed gearing it is the custom to employ striking forks A^4 attached to sliding selector rods A, A^2, A^3, each rod carrying one fork, there being generally two, and sometimes three, rods which require to be interlocked, so that when one rod is moved to engage a gear, accidental movement of the other rods and gears is positively prevented. The invention relates to interlocking mechanism of this kind, in which the selector rods A, A^2, A^3, have notches A^9 in their sides which mutually register when the rods are in neutral position and detents or locking bars C are



located between adjacent notches and, when either rod is moved, are displaced by it to engage the notches in the other rods and to lock them. According to this invention, the detent or locking bar C has a boss C^3 at each end and is guided upon rods C^2, extending through the bosses and located one above and the other below the selector rods. The spacing of the rods A, A^2, A^3, and the dimensions of the notches A^9 and bars C is such that only one rod can slide at a time, the bars C being then held in the notches in the other rods by engagement with the plain or unnotched part of the moved rod. The locking bars C and their guides are mounted in a cap A^6, which is detachably connected to the gear box or casing and serves also as a guide for the selector rods A, A^2, A^3. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

170,467. F. H. Addis, Bridlington. Couplings. (7 *Figs.*) September 4, 1920.—The invention relates to those couplings in which the relation of the coupling hook on one vehicle to the coupling pin on the adjacent vehicle can be adjusted when the hook is in engagement by means of a screw or other tightening device. The members 1 and 2 forming the coupling are flexibly mounted in the headstock 3. The locking member is in the form of a lever arm 10 carried by one coupling member and being pivoted to the lug 13 thereof is adapted to be engaged by



the hook 11 carried by the other coupling member. The relation of the locking member to the hook 11 is adapted to be adjusted by means of the screw 14 in order to put the hook member 11 under tension when in the coupled position. The action of the coupling is obvious from the drawings. The faces of the headstocks being brought into contact, the hook 11 falls into the slot in the opposite headstock and is firmly engaged by the member 10 which is itself locked by the adjusting of the screw 14. (*Sealed.*)